PHONOLOGICAL PRIMING OF PREEXISTING AND NEW ASSOCIATIONS IN YOUNG AND ELDERLY ADULTS

By

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Two experiments investigated phonological priming of preexisting and new associations in word retrieval. Young and older adults completed paired word stems with the first word that came to mind. Experiment 1 demonstrated phonological priming of preexisting associations by having participants complete word-stem pairs that contained homophones paired with the first letter of the opposite homophone's semantic associate (e.g., *beech-s*____). Experiment 2 demonstrated phonological priming of new associations by having participants first complete word-stem pairs that contained homophones paired with an unrelated first letter (e.g., *beech-l*____) and later complete word-stem pairs that contained the opposite homophone paired with the same unrelated first letter (e.g., *beach-l*____). Further, the dominance of the homophone pairs was manipulated in order to observe the effect of meaning dominance on phonological priming in word retrieval. Young and older adults demonstrated equivalent amounts of phonological priming in both experiments. Further, homophone dominance influenced phonological priming of preexisting associations but not new associations. These results suggest that older adults are not differentially disadvantaged on <u>implicit</u> tests of new association priming versus preexisting association priming.

CHAPTER 1
INTRODUCTION

Role of Phonological Priming in Word Retrieval

Over the past 20 years, cognitive psychologists have devoted considerable research to how people represent, recognize, and retrieve words, with specific interest in a word's ability to facilitate identification of other words (i.e., priming). Individual words can influence how we recognize and retrieve other words on a number of levels:

- Words similar in meaning show semantic priming (e.g., presenting the word *light* speeds processing of the semantic associate *lamp*).
- Words presented across two points in time show repetition priming (e.g., processing of the word *light* is faster if *light* was presented a few minutes earlier).
- Words similar in sound show phonological priming (e.g., presenting the word *light* facilitates processing of the word *write*).

Considerably less research exists on phonological priming than on semantic and repetition priming, especially for word retrieval and for elderly adults. Of the few studies that have been published, older adults appear to have more difficulty than young adults in retrieving the phonology of some low-frequency and nonrecently used words, leading to increased tip-of-the-tongue states (Burke, MacKay, Worthley, & Wade, 1991). Fortunately, older adults can benefit from recent exposure to the missing phonology (James & Burke, 2000; Rastle & Burke, 1996; White & Abrams, 2002). Investigating the role of phonology in word retrieval and the nature of age-related breakdowns across phonological representations is particularly important for remediating older adults' weakened phonological representations.

The distinction between word <u>recognition</u> and word <u>retrieval</u> is important in memory research. Visual word recognition involves processing the orthography (i.e., spelling) and phonology (i.e., sound) of a word, comparing the word with its stored lexical representation, and

processing the meaning of the word. In contrast, word retrieval is involved when a concept is to be expressed: Memory is searched and a word is chosen from the lexicon. Although word retrieval can feel effortless at times, it is thought of as a more controlled (effortful) process than the automatic process of word recognition. Therefore, word recognition is more often a less time-consuming process than word retrieval because word retrieval requires finding the appropriate word to represent a to-be-expressed concept.

By using phonological priming in a word <u>recognition</u> paradigm, researchers showed that a word's meaning can be automatically activated through a phonological code. For example, homophones (e.g., *beach, beech*) are words that differ in orthography and semantics, but share identical phonology. Researchers interested in whether people can access a word's meaning through a phonological code have used homophones to illustrate phonological priming in a word recognition task: Participants are asked to name a target word (e.g., *sand*) that is preceded by the homophone (e.g., *beech*) of a word that is semantically related to the target (e.g., *beach*). The response time to name a target (*sand*) that comes after its phonological prime (*beech*) is compared to the response time to name a target that comes after an unrelated prime (e.g., *batch*). Many studies showed that <u>both</u> words that share phonology (e.g., *beach, beech*) facilitate recognition of a word that is semantically related to only one of the words (e.g., *sand, nut*), indicated by faster naming times of and lexical decisions to the target (Lesch & Polatsek, 1993; Lukatela & Turvey, 1994). Thus, activation of *sand* occurs because the phonological representation for *beech* is activated before the lexical representation of *beech,* resulting in the spread of priming to all words that share connections to the phonological representation /bēch/ (e.g., *sand, nut*).

Research has yet to determine, however, whether phonological priming of this sort occurs in word <u>retrieval</u>. Although activation of a word's phonological representation may automatically occur upon visual presentation of the word, evidence suggests that orthographic (i.e., spelling) constraints direct word processing after approximately 200-250 ms (Lesch & Pollatsek, 1993).

Early in word recognition (within 200-250 ms of visual presentation), all lexical entries that share a phonological code are activated. According to one supported model, for word recognition to proceed, the lexical entry with the highest activation must go through a "verification process" where the written spelling is checked with the spelling that is stored in memory (Van Orden, 1987). If the two spellings match, the remaining (inappropriate) lexical entries are suppressed. However, the verification process takes time and therefore substitution errors from homophones can occur (i.e., meanings associated with both homophones are initially activated and one meaning is suppressed after the verification process has been completed). Evidence for this verification process comes from word recognition studies that showed phonological priming of semantic associates only when the phonological prime (e.g., *beech*) was presented less than 200-250 ms before the semantic associate target (e.g., *sand*) (Lesch & Pollatsek, 1993; Fleming, 1993; Lukatela & Turvey, 1994). For example, Lesch and Pollatsek (1993) found that at a 200 ms interval between the prime and target, the benefit of the phonological code (that was present at 50 ms) disappeared. These results suggest that phonological priming of semantic associates may be unobservable in word retrieval tasks because retrieval occurs across longer intervals and is more effortful than recognition (i.e., a to-be-retrieved word is searched for instead of simply identified).

The purpose of the present experiments was to demonstrate phonological priming of semantic associates using word-stem completion, a task that is commonly used to investigate word retrieval processes. In a traditional word-stem completion test, participants are given a portion of a previously studied word and are asked to respond with the first word that comes to mind. For example, if participants study *sandpaper* they might be given *san*_____ at test and be asked to complete the blank with the first word that comes to mind and begins with "*san*." Priming occurs when *san*_____ is completed more often with *sandpaper* after recent presentation of the word than after no exposure to the word.

One recent study used word-stem completion to test phonological priming of homophones with young adults (Rueckl & Mathew, 1999). This study presented participants with one meaning of a homophone and asked them to make a semantic judgment or a frequency rating on that homophone. After an intervening task lasting approximately 3 minutes, participants were given the first three letters of a series of words and asked to complete the word stems with the first word that came to mind. These first three letters corresponded to one of three categories:

- They were the first three letters of the homophone that was primed (e.g., *wea*__ if *weak* was presented).
- They were the first three letters of the corresponding homophone that was not primed (e.g., *wee*___ if *weak* was presented).
- They were stems of words that were not primed during the judgment or rating tasks (e.g., *wea*__ if neither *week* nor *weak* was presented).

All of their experiments showed that phonological priming occurred across meanings of a homophone, such that participants were more likely to complete a stem with *week* if they were presented with *weak* 3 minutes earlier. These studies support the notion that phonological priming can extend to retrieval processes, even after a 3-minute retention interval. However, Rueckl and Mathew's studies did not determine whether phonological priming of <u>semantic associates</u> occurs in a retrieval paradigm.

Phonological priming in word retrieval has also been used in the context of the tip-of-the-tongue (TOT) phenomenon. TOTs are retrieval failures where a word is known but is unable to be retrieved at the current moment (Brown & McNeill, 1966). Phonological priming of TOTs occurs when a word (e.g., *<u>ab</u>stract*) that shares a phonological component with the TOT word (e.g., *<u>ab</u>dicate*) facilitates retrieval of that word. James and Burke (2000) presented participants who were having TOTs with words containing similar phonology to the missing (i.e., target) word. For example, if participants were having a TOT for the word *abdicate*, they would read a list of ten words, five of which contained the phonology in *abdicate* (i.e., *<u>ab</u>stract, in<u>di</u>gent, trun<u>cate</u>, tra<u>di</u>tion, and lo<u>cate</u>*). Results indicated that participants were more likely to

resolve TOTs when presented with phonological prime words than when presented with unrelated words that did not contain similar phonology. Using a similar paradigm, White and Abrams (2002) found that young adults resolved TOTs after they were presented with primes that corresponded to the first syllable of the target word (e.g., *abstract*) but not to the middle (e.g., *indigent*) or the last (e.g., *locate*) syllables. These studies and others investigating TOTs suggest that TOTs are the result of an inability to retrieve the phonological components of a word, even when the meaning is activated (Burke, et al., 1991). Similarly, misactivation of phonological components can explain other language production deficits, such as slips of the tongue (Dell, 1986).

Research investigating word retrieval processes differentiates between retrieval for words and concepts that we already know (such as TOT words) and retrieval for words and concepts that we have just learned (such as new vocabulary words or new names). Indeed, retrieval processes involving these two types of materials can differ greatly from one another (i.e., retrieving words that one has just learned is more difficult than retrieving more familiar words). A theoretical framework of language perception and production, Node Structure Theory (NST; MacKay, 1987), provides an explanation for how people retrieve words that have a preexisting representation in memory versus newly learned words or words that require a new association in memory. People have preexisting representations, or connections, for words that share a relationship in their memory (e.g., the words *beach* and *sand* are semantically related, and the words *beach* and *beech* are phonologically related). In contrast, people must form a new association, or connection, when they learn new words or pair together two words that did not have a preexisting relationship (e.g., pairing *sand* with *kitchen* in the sentence, "The *kitchen* was covered in *sand* from the children's clothes.")

Node Structure Theory is a connectionist framework that represents words, their semantic representations, phonology, and orthography in a hierarchical system of nodes (i.e., hypothetical representations that store information in the brain) (Figure 1-1). In NST, a strong connection

exists between two words that have been previously related and that priming between these representations (i.e., nodes) is transmitted rapidly. Further, the stronger the connection between the representations, the faster the transmission of node priming. Hence, according to NST, people should be faster to recognize the word *sand* if they are primed with *beach* than if they are primed with *batch* because a preexisting semantic connection between *sand* and *beach* is more likely to exist. Interestingly, also makes theoretical predictions for the formation of new connections. Specifically, NST asserts that the connections between new associations are weaker because they have not been accessed and strengthened over time. Hence, priming between two newly associated words is slower and only occurs if the connection has been adequately formed.

Node Structure Theory is described in detail in this paper because it is one theory that specifically compares the retrieval of preexisting connections to the formation and retrieval of new associations within a single theoretical framework. However, other theories make similar claims about new association priming, although they do not necessarily make comparisons to the priming of preexisting associations. These theories (Graf & Schacter, 1985, 1989; Micco & Masson, 1991) maintain that new associations are identified both perceptually and conceptually, and must be unitized in order to show priming. Unitization requires representing distinct items as one unit (Graf & Schacter, 1989). Presumably, the more pairings of the new associations, the more unitized they become. Similarly, according to NST, the more pairings of the new associations, the stronger the connection between them becomes. Whereas Graf and Schacter (1985, 1986) found that the new associations required elaboration to unitize the association, Micco and Masson (1991) suggested that any encounter with the association should produce unitization.

Although theoretical views differ slightly in how new associations are formed and maintained, a general consensus exists with respect to priming of preexisting representations: Presentation of a word (*beach*) or semantically related word pair (*beach-sand*) activates (or primes, according to NST) an existing memory trace (or connection). In summary, there is

general agreement that priming of preexisting associations occurs at multiple levels (e.g., lexical, phonological, semantic) when an existing memory trace is activated, and priming of new associations requires formation of some connection or unitization of the newly associated words.

My experiments investigated phonological priming of preexisting associations and new associations in young and older adults using a word-stem completion paradigm. Experiment 1 demonstrated phonological priming of preexisting associations by having participants complete word-stem pairs that contained homophones paired with the first letter of the opposite homophone's semantic associate (e.g., *beech-s*____). Experiment 2 demonstrated phonological priming of new associations by having participants first complete word-stem pairs that contained homophones paired with an unrelated first letter (e.g., *beech-l*_____) and later complete word-stem pairs that contained the opposite homophone paired with the same unrelated first letter (e.g., *beach-l*_____). Further, the dominance of the homophone pairs (i.e., which member of a pair is thought of first upon hearing the phonology) was manipulated in order to observe the effect of meaning dominance on phonological priming in word retrieval. Homophone dominance has never been examined in a word retrieval paradigm, although meaning dominance does appear to affect how quickly meanings of homographs (e.g., *bass-fish*, *bass-guitar*) and homonyms (e.g., *bat-vampire*, *bat-baseball*) are activated in recognition tasks, such as semantic judgment (Gottlob, Goldinger, Stone, & Van Orden, 1999; see Sereno, Pacht, & Rayner, 1992 for an example of activation of dominant and subordinate ambiguous words within sentence contexts).

Because NST incorporates the distinction between preexisting and new connections into its theoretical framework, it allows for certain predictions to be made regarding phonological priming of homophones in a word-stem completion task. In contrast, other theories do not directly contrast preexisting and new connections and are therefore limited in their generalizability. Generally, NST predicts phonological priming of preexisting associations because activating the phonology for *beach* will spread priming to the phonologically identical

word *beech*, which will in turn send priming to its semantic associates (e.g., *sand*), which are strongly connected. Thus, phonological priming is expected between words and the semantic associates of their homophones (e.g., *beech-s*____). Node Structure Theory also predicts phonological priming of new connections to the extent that the new connection is formed and is sufficiently strong. Note however, that NST does not quantify how strong a connection must be in order to observe phonological priming. Node Structure Theory simply predicts that if a new connection is formed between *beech-l*_____ and is strong enough, then phonological priming should allow for the same stem completion when *beach-l*_____ is encountered (see "Predictions" subdivision of Chapter 5).

Phonological Priming and Aging

Studies on phonological priming in word retrieval are needed to allow researchers on aging to determine the following:

- The relationship between age and potential deficits in retrieval
- Which aspects of word retrieval contribute to potential age deficits in retrieval.

For example, word retrieval for infrequently used words has been investigated in elderly populations through the TOT procedure (Burke et al., 1991; Heine, Ober, & Shenaut, 1999; James & Burke, 2000; White & Abrams, 2002). These studies suggest that older adults have more difficulty retrieving infrequently used words and names than do younger adults. However, retrieval of more common words and their phonological connections has not been studied in older adults. Further, phonological priming of preexisting and new associations has not been studied in older adults. There is reason to suspect possible deficits with retrieval of phonology in old age because weak connections from phonology to words are proposed as a cause of age-related increases in word retrieval failures, such as TOT states (Burke et al., 1991). However, TOTs are most likely to occur for words that are not used very often or have not been used recently. One possibility is that older adults have retrieval deficits only for infrequently and nonrecently used words; the retrieval of more common words may be age-invariant.

Research using priming with older adults has been critical in determining cognitive stability versus declines because for many years young and older adults were thought to show equivalent priming in implicit memory tasks, contrary to large age-related declines seen in explicit memory tasks. For example, older adults show semantic priming equivalent to (if not greater than) that of young adults (Laver & Burke, 1993). However, recent reviews (Fleischman & Gabrieli, 1998) and meta-analyses (LaVoie & Light, 1994; Light, Prull, LaVoie, & Healy, 2000) suggested that age invariance does not occur for all implicit tasks. One way of explaining this has been to compare young and older adults on item versus associative priming tasks. According to Fleischman and Gabrieli (1998), "Item priming tasks indirectly measure long-term memory for single items that often have preexisting mental representations. Associative priming tasks indirectly measure learning of new associations between previously unrelated items and thus, do not have preexisting mental representations" (p. 94). For example, in an item priming task, participants might be asked to process the word *beach* early in the experiment and later be given a word stem to complete with the first word that comes to mind. Item priming is measured by the percent of time the stem *bea*______ is completed with the earlier-presented word, *beach*. This task simply requires people to access a preexisting connection to a single word. In contrast, participants involved in an associative priming task might be asked to learn word pairs (e.g., *beach-laugh*) and later be tested in a word-stem completion test for implicit memory of the pair (e.g., *beach-lau*____).

However, these definitions of item and associative priming do not capture the ability to access a <u>preexisting</u> connection between words within a <u>word pair</u>. As a result, direct comparisons between accessing preexisting associations and learning new associations had not been made within a single task (i.e., associative priming) before my experiments. My experiments presented an innovative twist to the traditional associative priming experiments by testing preexisting versus new connections <u>within</u> the associative priming paradigm. For example, <u>preexisting connections</u> were tested with a homophone (e.g., *beech-s*____) by assessing whether

the stem was completed with the semantic associate (e.g., *sand*) of the other spelling of the homophone. Preexisting connections are used in this case because the semantic associate (e.g., *sand*) shares an existing semantic connection with the nonpresented instance of the homophone (e.g., *beach*). In contrast, associative priming of <u>new connections</u> was tested by requiring participants to make a new connection between a homophone and the word they used to complete the stem (e.g., *beech-l<u>augh</u>*), which did not have a preexisting connection. Later retrieval of the same word (*laugh*) when completing the same word stem paired with the other spelling of the homophone (e.g., *beach-l*____) indicates associative priming across a new connection.

My experiments allowed me to directly assess priming of preexisting versus priming of new associations using the associative priming paradigm. Further, the experiments tested <u>phonological</u> priming of associations, rather than the frequently used <u>repetition</u> priming. Meta-analyses reported small age differences in repetition priming favoring young adults for both item priming and associative priming tests, with no differences between item and associative tests (LaVoie & Light, 1994; Light, et al., 2000). These results suggest that older adults are at a slight disadvantage in repetition priming tasks, but are not differentially disadvantaged when forming new associations (tested through associative priming) versus accessing preexisting ones (tested through item priming). However, this conclusion is confounded because item priming tests have always been used to investigate preexisting connections and associative priming tests have always been used to investigate new connections. One solution to this confound is to test preexisting versus new associations within an associative priming paradigm, which my experiments did.

Another issue related to age differences on associative priming tasks involves the potential use of explicit retrieval processes while completing implicit memory tasks. Many researchers caution that implicit tasks like word-stem completion are susceptible to contamination from explicit processes (Bowers & Schacter, 1990; Howard, 1991). That is, it is difficult to know whether participants are aware that they are completing a word stem with a previously studied word, and whether this awareness leads them to use conscious (intentional) strategies to complete

word stems with previously studied words. As long as explicit contamination is confounded with implicit memory tests, researchers cannot be confident that their results demonstrate pure implicit memory. Further, controlling for explicit contamination is especially important when comparing young and older adults because older adults are often less aware than young adults of the relationship between previously presented words and the memory test. Therefore, older adults are less likely to be able to use explicit strategies to the same extent as younger adults (Light & LaVoie, 1993), resulting in the appearance of age differences in implicit memory. My experiments implemented a new design to test implicit retrieval that was intended to reduce, if not eliminate, explicit contamination from a word-stem completion paradigm. Namely, these experiments did not include an explicit study phase that participants could think back to; instead, the entire experiment was an implicit word-stem completion "test" where participants simply gave their first-thought responses to associative word stems.

In summary, a large body of literature exists on semantic priming and repetition priming in both young and older adults. However, research investigating phonological priming in young and older adults is limited to a few previously described studies that assessed the effect of phonological priming on TOT resolution (James & Burke, 2000; White & Abrams, 2002). Although these studies used the implicit procedure of priming, they assessed the effect of priming on explicit retrieval of words when in a TOT state. I am aware of no aging studies that have attempted to determine whether phonological priming and/or activation of words is similar for young and older adults using a strictly implicit task (i.e., tests that do not require conscious recollection of previously learned material).

General Predictions of Two Cognitive Aging Theories

Node Structure Theory's general predictions regarding phonological priming of preexisting and new connections were previously described. One corollary of NST, the Transmission Deficit hypothesis (TDH; MacKay & Burke, 1990), extends these predictions to include the impact of aging on retrieval processes. Interestingly, TDH is the only hypothesis to

specify how aging affects the retrieval of preexisting and newly-formed connections. TDH maintains that the connections between nodes weaken with increasing age. Thus, transmission of node priming, including phonological priming, is predicted to be slower in older adults. It is important to note that slower transmission of node priming does not necessarily result in a lesser amount of priming for older adults. Rather, older adults might exhibit the same pattern of priming, but simply do so at a slower rate of transmission. TDH further asserts that new connection formation and the retrieval of new associations are more affected in aging. No research with older adults has investigated phonological priming among newly-formed connections, nor directly compared retrieval of new associations with retrieval of preexisting representations. Thus, it is important to specify how aging affects predictions within NST. In general, TDH predicts that older adults will not have deficits with retrieval of preexisting connections (Experiment 1). Activation of preexisting information occurs through committed nodes, i.e., nodes that are already committed to some representation. Connections to preexisting information have been continuously activated over an adult's lifetime, resulting in stronger connections that compensate for deficits in the transmission of node priming. Further, any retrieval deficits that have been identified for older adults (e.g., retrieval of TOT words) have been for infrequently or nonrecently used words. As a set of stimuli, homophones are more common words that should be frequently activated in adults of all ages.

In contrast to preexisting associations, in order for new learning to occur, uncommitted nodes (i.e., nodes that have no previous connections to them) must become committed through prolonged and continuous activation, a process referred to as commitment learning. Commitment learning is difficult because the connections to these nodes are so weak that they struggle to transmit priming effectively. Thus, if aging weakens the connections between existing nodes, reducing the amount of priming spread along these connections, then older adults will surely struggle in commitment learning (i.e., the formation of new connections). Hence, TDH predicts

that older adults should have difficulty forming new connections, and therefore will not likely show the phonological priming of new connections expected by younger adults (Experiment 2).

Although no other hypotheses (or theories) address the influence of aging on preexisting versus new connections, one other hypothesis makes predictions that are relevant to my experiments. The Inhibition Deficit hypothesis (IDH; Hasher & Zacks, 1988) maintains that older adults have difficulty inhibiting irrelevant information. Inhibition mechanisms allow people to limit the information that goes into working memory (WM) to pertinent information and not "non-goal-path thoughts" (p. 213). Normal inhibitory mechanisms help to dampen or suppress the information that is not relevant to the task at hand. Hasher and Zacks suggested two specific consequences of inefficient inhibitory mechanisms: the activation of irrelevant information, and the sustained activation of previously relevant and/or irrelevant information. For example, inefficient inhibitory mechanisms might allow the activation of multiple meanings of a homonym (e.g., *bank*) and the persistence of this activation because of an inability to suppress the "wrong" interpretation/meaning. Hasher and Zacks (1988) argued that people "with reduced inhibitory functioning can be expected . . . to make more inappropriate responses and/or to take longer to make competing appropriate responses. . . . " (p.215).

Since its conception, the IDH has been used to explain findings in attention, WM control, and language comprehension. Interestingly, priming research has seldom been used to confirm or disconfirm the IDH (Light et al., 2000). Because the IDH was rarely used to predict performance on priming tasks, my studies provided an excellent opportunity to make predictions for this model. Specifically, Experiment 1 used homophones in a WSC test to assess whether the shared phonology between two homophones primed the semantic associates of both homophones (e.g., whether /bēch/ primes *sand* and *nut*). According to the IDH framework, older adults would be expected to show <u>more</u> priming in this task, thus being more likely than young adults to complete a word stem with the semantic associate of a homophone's alternate meaning (e.g., complete *beech-s___* with *sand*). This prediction is consistent with descriptions by Hasher and Zacks

(1988) that older adults are more likely to activate both meanings of an ambiguous homonym (*bank*). Further, Experiment 2 tested the formation of new associations by seeing if participants used the same word (*laugh*) to complete a word-stem (e.g., *l*____) paired first with one meaning of a homophone (e.g., *beech-l*___) and later paired with the other meaning of the homophone (e.g., *beach-l*____). In this experiment, the IDH predicts that older adults should show more priming of new associations (i.e., more completions with the same target word) because of sustained activation from their first completion to their second completion.

In summary, the present experiments were the first to compare priming of preexisting and new associations using the same paradigm: word-stem completion. In addition, these experiments demonstrated phonological priming, not simply the repetition priming so often used with word-stem completion. Chapter 2 is a review of relevant literature on implicit memory and on aging.

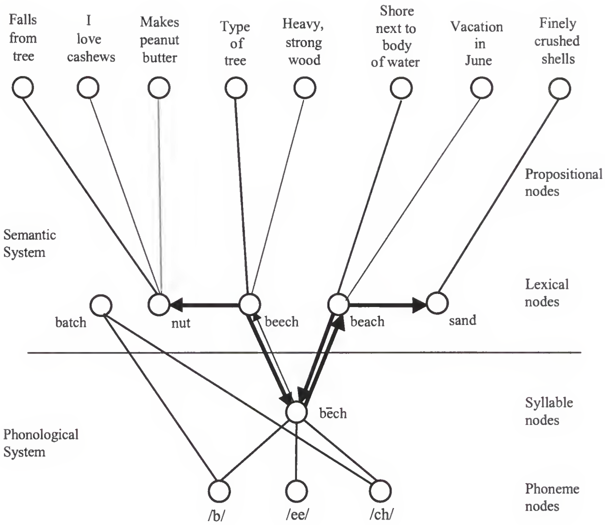


Figure 1-1. Node Structure Theory's hierarchical network. An example of Node Structure Theory's hierarchical network for the homophones *beach* and *beech*. This figure shows how priming should spread for preexisting associations discussed in Experiment 1. More priming of semantic associates occurs for subordinate homophones than for dominant homophones because priming must travel to the phonology and then across the connection to the dominant homophone, which is a stronger connection than that from the phonology to the subordinate homophone. However, strong connections exist between each homophone and their semantic associates.

CHAPTER 2
LITERATURE REVIEW

Overview of Implicit Memory

Implicit memory is generally studied using a priming paradigm, where a person's response to a stimulus (e.g., a word) is measured after a previous encounter with that stimulus or a similar stimulus (e.g., a synonym). Specifically, traditional priming paradigms present participants with a stimulus during an early (study) phase of the experiment, and later test their performance on some task that requires production or perception of this stimulus. For example, priming is demonstrated when participants respond faster to the word *shirt* when they have encountered *shirt* earlier during the experiment than when they have not encountered *shirt*. Although the study phase is often explicit (e.g., participants are asked to count the number of vowels in the prime words or are asked to make a sentence using a prime word), the test phase is implicit because participants are asked to respond to words without consciously thinking back to the study phase. Priming can occur for both single words (i.e., item priming, e.g., study *shirt* and respond to *shirt* at test) and for word associations (i.e., associative priming, e.g., study *shirt-desk* and respond to *shirt-desk* at test). Most implicit tests are designed to require a speeded response on the assumption that implicit processes are more likely to be utilized when people do not use conscious retrieval strategies. Other tasks, such as word-stem completion (WSC), are assumed to tap implicit memory even though they are not speeded per se. The WSC test is commonly used to study associative priming and requires people to fill in an incomplete word (e.g., *pic*___; or an incomplete word paired with another word, e.g., *tree-pic*____) with the first word that comes to mind. Asking people to use the first word that comes to mind is intended to prevent them from using conscious retrieval strategies.

Early memory researchers used a wide variety of tests to define a number of levels of priming. Critical for the present experiments are repetition priming, semantic priming, and phonological priming. Repetition priming occurs when a participant's response to an item is facilitated after previous presentation of that same item (e.g., *doctor-doctor*; Jacoby & Dallas, 1981; Kirsner & Smith, 1974; Warrington & Weiskrantz, 1974). Similarly, semantic priming occurs when a response is faster to a target word when preceded by a semantically related prime word than when preceded by an unrelated word (e.g., *doctor-nurse*; Fischler, 1977; Meyer & Schvaneveldt, 1976). Finally, phonological priming occurs when a word similar in sound to a target facilitates response to the target (e.g., *couch-pouch*; Meyer, Schvaneveldt, & Ruddy, 1974).

Phonological Priming in Word-Stem Completion and Word Recognition

A useful tool for exploring the interaction of phonology with semantics and orthography is homophones. Homophones (e.g., *week*, *weak*) are words that differ in orthography (spelling) and semantics (meaning), but share identical phonology (sound). Homophones allow for a "pure" assessment of phonological priming because they share the exact phonology, in contrast with phonologically similar words (e.g., *sun, fun*) that differ by at least one phoneme. Further, using homophones allows one to investigate the effects of orthography and/or semantics on lexical access while keeping phonology constant. The effects of phonology on word recognition have been extensively investigated using homophones (Lesch & Pollatsek, 1993; Lukatela & Turvey, 1994; Van Orden, 1987). In contrast, very few studies (Davis, Cohen, Gandy, Colombo, VanDusseldorp, Simolke, & Romano, 1990; Howard, 1988; Jacoby & Witherspoon, 1982; Rose, Yesavage, Hill, Bower, 1986; Rueckl & Mathew, 1999) have used homophones in word retrieval, and even those that have did not investigate phonology's influence on the activation of semantics. The next subdivision, "Phonological Priming and Word-Stem Completion,"discusses three studies evaluating phonology in WSC:

- One using homophones where participants "study" one meaning of a homophone and are tested on their retrieval of the other meaning (Rueckl & Mathew, 1999)

- One using rhymes to prime WSC (Mandler et al., 1986)
- Another that is strictly concerned with the general importance of phonology in WSC tasks (Brooks et al., 1999).

I describe these three studies and then summarize the use of homophones to investigate semantic access in the word recognition literature is presented.

Phonological Priming and Word-Stem Completion

As mentioned in Chapter 1, Rueckl and Mathew (1999) used homophone pairs to assess phonological priming over a period of minutes. Interestingly, theirs is one of the few studies to use homophones in a production paradigm (see Davis et al., 1990; Howard, 1988; Jacoby & Witherspoon, 1982; Rose et al., 1986 for homophone production in a spelling test). Recall that Rueckl and Mathew (1999) primed participants with one meaning of a homophone (e.g., *weak*) and later asked participants to complete a series of word stems (e.g., *wea*___) with the first word that came to mind. They found that priming occurred across meanings of a homophone, supporting the notion that phonological priming occurs in an implicit test involving word production. However, Rueckl and Mathew did not assess whether homophones could prime retrieval of semantic associates (e.g., can *beech* prime retrieval of *sand*?), as was investigated in Experiment 1.

A series of studies by Mandler and his colleagues (Mandler, Graf, & Kraft, 1986; Mandler, Hamson, & Dorfman, 1990; Overson & Mandler, 1987) demonstrated phonological priming in WSC after participants studied words that rhymed with the target under semantic and nonsemantic rating conditions. For example, participants who rated words such as *moat, gloat, bloat,* and *oat* were more likely to later complete the stem *coa*__ with *coat* than participants who had not rated the rhymes. Although this priming disappears after ten minutes (Mandler et al., 1986), Mandler and his colleagues demonstrated that phonological priming can occur in a WSC task.

Independent of phonological priming per se, Brooks, Gibson, Friedman, and Yesavage (1999) were interested in the different types of word-specific characteristics (e.g., pronounceable

syllables) that might affect WSC. Specifically, Brooks et al. used WSC to study priming of words that contained "phonemic" or "dysphonemic" word stems. Phonemic stems are those three-letter stems that are pronounced the same in isolation as in word context (e.g., *leg* for *legacy*; *mus* for *mustard*). In contrast, dysphonemic stems are those that are not pronounced the same in isolation as in word context (e.g., *leg* in *legend*; *mus* in *mushroom*). Brooks and colleagues' (1999) question was whether these stems would differentially affect priming on a WSC test. Across a variety of study conditions (e.g., counting the number of syllables in a word, indicating whether a word contained a specific letter), the amount of priming for phonemic stems was almost three times that for dysphonemic stems (although dysphonemic stems did show priming). Further, no difference in priming between phonemic and dysphonemic stems was found when the stems contained four letters, suggesting that the "deficit" of dysphonemic stems is eliminated when the dysphonemic quality of the word is removed. Together, their results suggested that retrieval of words in a WSC paradigm is facilitated when the pronunciation of isolated syllables is preserved in the word stem.

<u>Phonological Priming in Word Recognition</u>

Because there are no experiments investigating phonological priming of semantic associates in word <u>retrieval</u>, relevant comparisons can be made with knowledge of similar paradigms in word <u>recognition</u>. Word recognition researchers found evidence suggesting that semantic associates of both meanings (*sand, nut*) of a homophone can be primed with presentation of either homophone (*beach, beech*).

These researchers (Humphreys, Evett, & Taylor, 1982; Lesch & Pollatsek, 1993; Lukatela & Turvey, 1994) used homophones in a short-term priming paradigm (within 250 ms of word presentation) to demonstrate that word recognition is facilitated by presenting a phonologically related prime. For example, Humphreys et al. (1982) briefly presented homophone pairs using a masked priming technique, where a mask (fragments of mixed upper and lower case letters) is shown, followed by a prime and a target, then another mask.

Humphreys et al. (1982) found that a word was more likely to be correctly identified if it was preceded by its homophone (e.g., *maid-made*) than by an orthographic control (e.g., *mark-made*). Van Orden (1987) demonstrated an interaction between phonology and semantics by investigating whether homophones could be misclassified based on their meanings. Van Orden used a semantic verification task where participants were presented with categories followed immediately by examples of those categories to which they had to make a yes/no response and then name the target. On critical trials, participants first saw a category (e.g., *flower*), then saw a homophone of an example of that category (e.g., *rows*). Van Orden found that homophones were misclassified as belonging to the semantic category significantly more often than orthographic control words (e.g., *robs*) were. This finding was the first evidence that activating a word's phonology (e.g., /rōz/) sends activation to words that have corresponding semantic relationships with that phonology (e.g., *flower*, *columns*).

Further examples of semantic access through phonology were demonstrated in paradigms where a homophone (e.g., *thrown*) is used to prime a target word (e.g., *king*) that is semantically related to the other homophone (*throne*) (Lesch & Pollatsek, 1993; Lukatela & Turvey, 1994). In this task, participants see a homophone prime and are asked to name a target word; the time taken to name a target word after seeing a homophone prime is compared to the time taken to name a target word after seeing an orthographic control prime word. Activation of *king* occurs because the phonological representation for *thrown* is activated before its lexical representation, resulting in spreading of priming to all lexical entries that share connections to the phonological representation /thrōn/ (e.g., *king* for *throne*, *ball* for *thrown*). Lesch and Pollatsek (1993) interpreted their results as evidence that semantic information about both homophones is automatically made available when the participant sees just one of the homophones. However, this phenomenon is short-lived and occurs only within brief presentation intervals (i.e., less than 200-250 ms between prime and target presentation). As discussed in Chapter 1, word recognition undergoes a spelling check (i.e., the verification process) after this brief interval: the spelling of

the most highly activated lexical entry is checked against the stored spelling representation. Further evidence for the verification process (Van Orden, 1987) comes from a series of experiments conducted by Lukatela and Turvey (1994).

Using the homophone word recognition paradigm described above, Lukatela and Turvey (1994) assessed the effect of homophone frequency on the activation of semantic associates. Frequency was defined by how often the homophone occurred in the English language. Van Orden's (1987) verification model predicts that the verification process should occur at a faster rate for the higher-frequency homophones than the lower-frequency homophones because high-frequency words are recognized faster and therefore their spellings are checked sooner than low-frequency words. In other words, the appropriate lexical entry is selected faster for high-frequency words than for low-frequency words, allowing other lexical candidates that share phonology with the high-frequency word to be suppressed at a faster rate. Thus, at longer intervals between presentation of the prime and target, high-frequency homophones should prime their partner's semantic associate less than low-frequency homophones should prime their partner's semantic associate. Lukatela and Turvey's results were consistent with their predictions, suggesting that orthography influences target naming faster for high-frequency words. This evidence supported Van Orden's verification model, namely, that the lower-frequency homophone is more likely to prime the associate of its higher-frequency partner because the orthographic verification process is slower for the lower-frequency homophone.

Gottlob, Goldinger, Stone, and Van Orden (1999) tested the dynamics between phonology and semantics by using a semantic priming paradigm with homographs (i.e., words that have the same spelling but different pronunciations and meanings, e.g., *wind*) and homonyms (i.e., words that have the same spelling and pronunciations but different meanings, e.g., *spring*). Gottlob et al. (Experiment 2) used an association task that required participants to say two words consecutively and to respond "yes" if they were semantically related. The associations included homographs that were paired with an associate that corresponded to either the dominant or the

subordinate meaning of the homonym/homograph. Gottlob and colleagues' dominant and subordinate associates were taken from norming studies where participants had to either write down the first (Nelson, McEvoy, Walling, & Wheeler, 1980; Wollen, Cox, Coahran, Shea, & Kirby, 1980) or first four (Gorfein, Viviani, & Leddo, 1982) meanings that came to mind when they read the homonym/homograph. In these studies, the dominant associate corresponds to the meaning of the first or only word that is written down. For example, Gottlob et al. followed the word *wind* by either *breeze* (dominant meaning) or *turn* (subordinate meaning). In order to respond "yes" (i.e., the two words are semantically related), one meaning had to be suppressed. For homographs, if the pronunciation and meaning for /wind/ is activated, a fast response to *breeze* is expected; however, if /wīnd/ is activated, longer responses will result. Similarly, if both meanings of a homonym are activated when the homonym is encountered, one meaning (e.g., *coil* for *spring*) must be suppressed in order to respond "yes" to another meaning (e.g., *season*).

Gottlob and colleagues' (1999) results indicated that dominant relationships were detected faster and more accurately than subordinate ones for both homographs and homonyms, but the effect was considerably smaller for homonyms. Gottlob et al. interpreted these results in terms of the dynamics between sound and meaning, such that phonology helps access the dominant meaning for homographs and hurts access to the subordinate meaning. Thus, if the "correct" homograph interpretation is activated, responses are speeded; if the "incorrect" interpretation is activated, responses are slowed. In contrast, homonyms are always pronounced the same (and the phonology always matches the target meaning) so the effect of dominance is not as pronounced (but still occurs, possibly because the dominant meaning is activated slightly faster than the subordinate meaning due to greater frequency of use of the dominant meaning). Although Gottlob et al. did not use homophones, the present studies allowed for an assessment of dominance in words that share phonology (like homonyms) but do not share orthography (unlike homonyms).

Implicit Memory for New Associations

Thus far, the discussion of implicit memory has focused on tapping preexisting representations in memory. However, researchers are not only interested in priming effects for existing knowledge, but are also interested in whether priming occurs for new information. Implicit memory for new associations is traditionally studied in an associative priming paradigm, where people learn new associations between words (in or out of context), and their memory or learning of these associations is later tested through one of the popular implicit tests. Learning of new associations has been investigated with multiple implicit memory tests such as naming and word-fragment completion, although WSC is of most interest here. When WSC is used to assess priming of new associations (e.g., *mother-calendar*), it is altered from its traditional form, such that the target stem is attached to a prime word (e.g., *mother-cal*____). When a word stem is paired with another word, it is often called associative WSC, or paired WSC. Priming of new associations is tested by comparing a condition where the pair is intact (i.e., the same words are paired at study and test) to a condition where the pairs are recombined (i.e., one word of a pair is repaired with a word from a different pair). Evidence is found in favor of new association formation if priming occurs for the intact pairs above the recombined pairs. In addition, the advantage of intact pairs over recombined pairs can be attributed to the associative relation between them and not just an advantage of being studied or exposed earlier (since all words are exposed).

A review of some of the studies investigating priming of new associations follows. Many of the early studies found that elaborative processing of word pairs during study was required for the formation of new associations. However, these studies used WSC as the test of associative priming. More recent studies using different (more perceptually based) tests showed implicit learning of new associations that is not dependent on elaborative processing (Goshen-Gottstein & Moscovitch, 1995; McKone & Tyrnes, 1999; Poldrack & Cohen, 1997).

Early studies investigating new associations found that elaborative processing was required in order to demonstrate priming (Graf & Schacter, 1985; Schacter & Graf, 1986, 1989). These studies required participants to study unrelated word pairs (e.g., *jail-strange*) that were later tested in a paired stem-completion test (e.g., *jail-str*______). More priming was consistently found in the same-context condition (where the pairs matched at study and test) than in the different context condition (where the pairs did not match at study and test, e.g., *poster-str*______), but only when participants semantically elaborated on the pairs during study. In Graf and Schacter's studies, priming was found for a variety of elaboration types, including generating a one-word link between the pairs, reading a sentence, and generating a sentence; however, priming was not found when the task at study did not require elaboration, e.g., when participants were asked to count the vowels in the words or rate the pleasantness of the words in each pair.

In contrast to these earlier studies, other researchers have demonstrated priming of new associations without elaborative processing at study (Goshen-Gottstein & Moscovitch, 1995; McKone & Tyrnes, 1999; Micco & Masson, 1991; Poldrack & Cohen, 1997). Poldrack and Cohen (1997) used a reading time manipulation that required participants to read word pairs twice during "study," then read either intact pairs (as presented at study) or recombined pairs (i.e., words were re-paired with different words from the study list) at "test." Experiment 1 found that reading time decreased across the two study lists, and that the "test" list with intact pairs was read faster than the test list with recombined pairs. These results suggest that new associations can be formed in just two presentations, and that elaborative processing at study is not required to show an improvement in performance at test (see Goshen-Gottstein & Moscovitch, 1995, for evidence of new association priming using lexical decision).

In conclusion, researchers remain puzzled by why some studies find that elaboration is required to form new associations (Graf & Schacter, 1985) and why others find evidence of learning without elaboration (Poldrack & Cohen, 1997). There are many possibilities that could account for the discrepancy: (1) elaboration may be required on tests that require retrieval of a

response (e.g., WSC) and not on tests that only require identification of a stimulus (e.g., naming, lexical decision) (Fleischman & Gabrieli, 1998), (2) elaboration could be necessary for tests that are preceded by a study phase, but not for tests that require the same response (e.g., reading) for each presentation of the stimulus, and (3) elaboration may affect WSC because this test has been shown to be influenced by explicit processes and is not a "pure" measure of implicit memory. The present studies should begin to shed light on this puzzle if priming is found with a production measure (WSC) and with a "test" phase that is not preceded by a "study" phase. Furthermore, the newer version of WSC used in the present experiments is a more "pure" measure of implicit retrieval that may not require elaboration to demonstrate priming.

Implicit Memory and Aging

Research on how implicit memory is affected by aging began after the surge of research on implicit memory in young adults (and amnesics) in the 1980s. In fact, implicit memory received so much attention during that time because amnesics, who had impaired explicit retrieval, often showed spared implicit memory (Warrington & Weiskrantz, 1974). It was around the same time that aging researchers reported that older adults were impaired on explicit (recall and recognition) tests of memory (Canestrari, 1966; Rabinowitz, 1986; see Salthouse, 1991, for a review). Thus, these researchers began to investigate whether a similar pattern of impaired explicit but spared implicit memory would be found in older adults. As expected, early studies did show age invariance on implicit tests (Light, Singh, & Capps, 1986; Light & Singh, 1987). Unfortunately, as additional studies emerged, the umbrella statement of "spared implicit memory" was challenged. Further, the past 15 years of research has not revealed any systematic age-related patterns across implicit memory tests or across different types of priming (e.g., item, associative). Although the majority of studies suggest age invariance, other studies report age deficits.

Studies Investigating Item Priming

Most studies investigating item (i.e., single word) priming have found no age differences across a broad range of tasks, including word-fragment completion (Light, Singh, & Capps, 1986), word-stem completion (Dick, Kean, & Sands, 1989; Java & Gardiner, 1991; Light & Singh, 1987; Park & Shaw, 1992), lexical decision (Moscovitch, 1982), category judgments (Rabbitt, 1982, 1984), perceptual identification (Hashtroudi, Chrosniak, & Schwartz, 1991, Experiments 1a and 2a; Light, LaVoie, Valencia-Laver, Albertson-Owens, & Mead, 1992; Light & Singh, 1987), anagram solution (Java, 1992), homophone spelling (Howard, 1988), and category association (Light & Albertson, 1989). Nevertheless, other studies have found age differences (favoring young adults) in item priming on tasks such as word identification (Abbenhuis, Raaijmakers, Raaijmakers, & van Woerden, 1990), word-stem completion (Chiarello & Hoyer, 1988; Davis et al., 1990; Friedman, Snodgrass, & Ritter, 1994; Hultsch, Masson, & Small, 1991; Titov & Knight, 1997), homophone spelling (Howard, 1988; Rose, Yesavage, Hill & Bower, 1986), and reading inverted words (Hashtroudi et al., 1991). The reason for these discrepancies is not clear; however, one argument attributes the null findings to often-used small samples (e.g., Light et al., 1995 who had 18 adults in each age group). Larger samples are critical in priming studies where age differences, if any, are consistently small. However, even some studies with large samples (e.g., Park & Shaw, 1992, N = 287) have found equivalent item priming in both young and older adults.

Word-stem completion has been one of the most commonly used tests to study item priming for young and older adults. Similar to the methodology used with young adults, these studies have young and elderly adults study single words under semantic or structural encoding conditions (Chiarello & Hoyer, 1988; Light & Singh, 1987; Java & Gardiner, 1991; Moscovitch et al., 1986; Park & Shaw, 1992; Titov & Knight, 1997). For example, participants will study a word (*computer*) by counting the number of vowels or rating the word's pleasantness, and will later be tested with the three-letter stem of that studied word (*com*___). Only one item priming

study using WSC has asked young and older adults to "study" words under implicit conditions: Hultsch, Masson, and Small (1991) had adults perform a lexical decision task to words and nonwords during the study phase, then measured item priming through WSC (and found a small but significant priming effect favoring young adults). Surprisingly, I am aware of no experiments that have investigated whether potential age differences in item priming could be due to explicit vs. implicit study conditions. The difficulties that older adults have with explicit study conditions (Howard, Fry, & Brune, 1991) could conceivably affect their performance on implicit tests, causing worse performance than when study conditions require implicit coding. In other words, any problems that older adults have with implicit tests following explicit study conditions might be eliminated if "studying" is done under implicit conditions. One possible explanation for why older adults might have difficulty when explicit study is required concerns the amount of explicit contamination that might occur during implicit testing. That is, if both young and older adults use explicit retrieval processes (i.e., thinking back to the previous study session) on implicit tests, young adults will most surely show an advantage because of their superior explicit skills. Thus, the potential for explicit contamination in any implicit test is an important methodological consideration that might be eliminated if the study session is also implicit.

A unique paradigm was developed by Jacoby and Witherspoon (1982) that used homophones to investigate item priming, and has since been employed by three researchers using young and older adults. These studies have followed a common methodology: Participants are exposed to the less frequent meaning of a homophone during a "study" phase and are later tested for their implicit memory of those items through a spelling test. The study phase usually requires participants to complete a general knowledge test that presents the biasing homophone embedded in the questions (Davis et al., 1990; Rose et al., 1986), or asks participants to answer a series of aurally-presented questions that bias one meaning of a homophone (e.g., "If you were making pizza, which kind of cheese would you *grate*?; Howard, 1988). Homophone bias is tested in a subsequent spelling test that allows researchers to assess which meaning of the homophone

participants access when they hear a homophone. Unfortunately, these studies have produced conflicting results. One study found a 12% bias towards producing the less frequent (primed) homophone for young adults but a insignificant – 4% bias for older adults (Rose et al., 1986). Another series of studies found age differences when explicit contamination was likely but no age differences when the potential for contamination was reduced (Howard, 1988). A final study could not assess age differences because older adults had a high baseline spelling that potentially obscured priming effects (i.e., they spelled the low-frequency homophone without priming as much as they spelled that homophone with priming, unlike young adults who were more likely to use the low-frequency spelling after priming; Davis et al., 1990). The only explanation for these discrepant findings that was provided by the authors was one of "procedural differences" (Howard, 1988).

Studies Investigating Associative Priming

The possibility of age deficits in associative priming emerged from findings that older adults showed deficits on explicit tests of new information (Canestrari, 1966; Rabinowitz, 1986; see Salthouse, 1991, for a review). However, researchers were uncertain whether these deficits were due to the formation of new associations or the retrieval of them. Finding preservation in the implicit formation of new associations would suggest that older adults do not have a problem establishing new connections: they are able to learn new information, but a deficit surfaces when asked to retrieve this information. Unfortunately, there are fewer studies comparing young and older adults on associative priming tests than on item priming tests, and the studies that have been completed yielded mixed results. Some studies found age invariance on associative priming (Balota & Duchek, 1989; Hasher & Zacks, 1988; Howard et al., 1991; Howard, Heisey, & Shaw, 1986; Moscovitch, Winocur, & McLachan, 1986; Nilsson, Backman, & Karlsson, 1989; Rabinowitz, 1986), whereas others found age differences favoring young adults (Howard, 1988; Howard, Fry, & Brune, 1991; Howard, Heisey, & Shaw, 1986; Moscovitch et al., 1986; Spieler &

Balota, 1996, Experiment 2). Even findings with WSC are inconsistent: Some studies found age differences in associative priming of WSC when study time was limited or there was only one presentation of the stimuli (Howard et al., 1986; 1991), while other studies found age invariance after a single study opportunity (Light et al., 1995, 1996).

Associative priming is assessed by having young and older adults either (1) explicitly study word pairs in a context, such as a sentence linking the pairs (Howard et al., 1986, 1991), or (2) implicitly study word pairs or nonwords by reading or naming the pairs without a context (Light et al., 1995, 1996; Spieler & Balota, 1996). For example, Howard and her colleagues (Howard et al., 1986; 1991) found that older adults exhibited deficits when asked to learn new associations under time pressure or non-optimal study conditions. Her experiments required young and older adults to study sentences such as "*The dragon sniffed the fudge*" for varying time intervals (e.g., 8 s, 15 s, or unlimited time) or to generate their own sentence linking the words *dragon* and *fudge*. Priming was assessed through a WSC test where a previously studied word was paired with the stem of its partner word (e.g., *dragon-fud*___). Generally, Howard found that older adults showed equivalent priming with young adults only when older adults were given unlimited time to study.

In contrast to Howard's original assumption that older adults require more study time to explicitly form new associations, other studies showed that older adults can form new associations under implicit study conditions such as naming (Light, LaVoie, & Kennison, 1995; Light, Kennison, Prull, LaVoie, & Zuellig, 1996). These studies asked young and older adults to pronounce word pairs (Spieler & Balota, 1996) or nonwords that were either new compound words made of single-syllable words (e.g., *fishdust*, *waygirl*), or nonwords made of different syllables from two-syllable words (e.g., *kennel* and *obsess* swap syllables to become *kensess* and *obnel*) (Light et al., 1995, 1996). Age invariance in associative priming was found in Light and colleagues' experiments after only one study presentation where participants were asked to pronounce the items as quickly and accurately as possible. However, these results were

challenged by a similar study that used unrelated (prime-target) word pairs as stimuli and found that older adults did not show evidence of new association formation across four learning trials (Spieler & Balota, 1996, Experiment 2). Unfortunately, Spieler and Balota's (1996) study cannot distinguish between whether older adults did not form new associations because of an age-related deficit, or whether they did not explicitly process the prime word because they were only asked to name the target. (Although Spieler and Balota included random cued-recall trials where participants were asked to recall the prime and target, older adults performed significantly worse on this task than young adults, suggesting they may not have explicitly processed the prime word to the same extent as the young adults). Hence, most of the evidence suggests that older adults do not show deficits in priming of new associations when "study" and "test" conditions are implicit (Light et al., 1995, 1996). Interestingly, Light and colleagues' stimuli were nonwords and therefore involved the formation of a new connection between the words or syllables constituting the nonwords, but did not require participants to make associations between words, as in the present experiments.

In summary, the few studies exploring associative priming have manipulated variables such as explicit learning (e.g., generating sentences to learn word pairs) or implicit learning (e.g., naming) of associations, and type of test (e.g., naming, WSC). Interestingly, because of the differences found between Howard's studies (where participants explicitly formed new associations) and Light and colleagues' studies (where adults implicitly formed new associations), one might suggest that the differences are related to the type of learning situation. Possibly, learning of new associations may be exhibited if both study and test are implicit situations (as in Light and colleagues' studies), whereas new learning may be difficult when studying is explicit and testing is implicit (as in Howard's studies). However, the data are currently too limited to draw any general conclusions in this area, a point that is reiterated in a meta-analyses of item and associative priming by Light et al. (2000).

Because of the discrepant findings on both item and associative priming tests of implicit memory in older adults, researchers have been unable to make blanket statements about which processes are spared and which are impaired in older adults. Further, although age differences are sometimes found on both types of tests, they are often very small in magnitude, leaving researchers to question their validity, especially when compared to the larger differences found with explicit tests. Fortunately, Light and her colleagues (2000) included a comparison of item and associative priming in a recent meta-analysis.

Light, Prull, LaVoie, and Healy's (2000) meta-analysis reported effect sizes on 95 published studies, of which 89 remained after excluding for outliers (i.e., those studies that contribute to a lack of homogeneity among all effect sizes, Hedges & Olkin, 1985). They found a mean weighted effect size of .185 (confidence interval from .133 to .237), suggesting a small but significant difference between young and older adults on indirect tests of memory. In addition to reporting this overall effect size for implicit tests, the authors compared priming effects along a number of dimensions, including item vs. associative priming. Light et al. (2000) found that item and associative priming did not differ in magnitude, with effect sizes of .205 (range .150 to .261) for item priming and of .224 (range .094 to .354) for associative priming. This finding suggests that older adults are not differentially affected by tasks that require learning new information versus activating preexisting connections, and that both tasks show age declines. However, these effects should be interpreted with caution for at least two reasons. First, there were only seven tasks used to assess associative priming, and many of these tasks were only used in one experiment; in contrast, 13 different tasks were used in the item category. There appears to be a need for a larger variety of associative tasks and more use of the existing tasks. Second, all associative tasks except WSC used latency as their dependent measure, whereas the item priming tasks used a mixture of latency and "other" measures (Light et al., 2000, p. 256). Because age deficits are not generally found on latency measures but are found on "other" measures, further dividing this dichotomy by type of dependent measure would be an interesting contrast.

Semantic Priming and Aging

As noted previously, most of the research on implicit memory in aging has focused on repetition priming. Another area of priming that has been investigated in old age is semantic priming. The studies that have investigated semantic priming in young and older adults find (at a minimum) preserved semantic priming in older adults. Specifically, studies have found that spreading activation processes between semantically related words remain constant throughout adulthood (Balota & Duchek, 1988), and that older adults show a slight advantage in semantic priming tasks (Laver & Burke, 1993). Although older adults take longer to begin and to finish pronouncing a word, the characteristics of activation (i.e., more priming from words that are strongly semantically related vs. weakly semantically related; time course of activation) are similar to those for young adults. Thus, the findings that older adults are slower in lexical access but activation is spared in old age explain why older adults benefit more from semantic priming. That is, seeing a prime word prior to a target gives older adults a "head start" to accessing the target. This result was confirmed in a meta-analysis of semantic priming effects performed by Laver and Burke (1993). Older adults showed slightly more semantic priming than young adults (effect size of .10 with 95% confidence interval from .04 to .17). This finding is consistent with the idea that semantic priming helps older adults compensate for their slower sensory processes (e.g., slower at word recognition).

Laver and Burke (1993) offered an explanation of their results according to the Transmission Deficit hypothesis of aging: The amount of priming transmitted between nodes is determined by the strength of the connections, and age weakens the transmission of priming, slowing the retrieval of information. Anyone (especially older adults because of the wealth of information they have accumulated over a lifetime) can offset the transmission deficits if they have multiple connections to a target node (i.e., have many semantic associations to a concept). Older adults' more intricate architecture allows them to offset transmission deficits and benefit more from semantic priming accumulating from many associations onto a target node. In

addition, because older adults take longer to respond, this time increase allows them more time to accumulate priming from their many semantic connections, also giving them a "boost" relative to younger adults. Laver and Burke concluded that a semantic prime allows for a context that can reduce any sensory or recognition deficits that older adults have, and that the summation of priming from multiple semantic nodes offsets any age-related deficits, allowing older adults to show semantic priming.

Summary of Experiments

I now return to the three goals of the experiments presented in this paper. First, the experiments investigated the effects of phonological priming on word retrieval. Word retrieval was assessed in two experiments that incorporated a modified WSC paradigm. Experiment 1 investigated phonological priming of preexisting associations, and Experiment 2 investigated phonological priming of new associations. A further subgoal with regard to phonological priming was the use of WSC as the dependent measure in both experiments, which permitted a comparison of phonological priming across preexisting phonological and newly-formed associations. Previous measures of associative priming only assessed the formation of new associations.

Second, these experiments (most specifically, Experiment 2) tested a novel application of a traditional implicit memory test in young and elderly adults, which greatly reduced, if not eliminated, the possibility of explicit contamination or strategy use. Previous studies employing WSC tests of implicit memory have failed to convince researchers that the processes involved at test completion are independent of explicit retrieval strategies (Bowers & Schacter, 1990). This issue is especially relevant to age comparisons because older adults are less capable of utilizing explicit retrieval strategies.

Finally, these experiments provided important data on which a larger research program could be based and by which future investigations into the nature of phonological representations

in young and elderly adults could be conducted. A recent review cited only four published experiments investigating associative priming with WSC in young and older adults, and these studies yielded conflicting findings with regard to age differences (Fleischman & Gabrieli, 1998). The present studies began to tease apart why age differences occur with associative priming in WSC: First, would age differences be found when participants were not given an explicit study phase? Howard et al. (1991) suggested that older adults' difficulties with associative WSC occurred when they were not allowed sufficient time to elaborate on study items. The present studies gave older adults a chance to demonstrate associative priming under conditions that involved minimal effort. Second, would age differences be found when associative priming involved access of preexisting associations rather than the formation of new ones? Previous studies always required the formation of new associations when using associative priming in WSC. The present studies not only assessed new association priming, but also added a new dimension by investigating priming of preexisting associations.

Prior to conducting Experiments 1 and 2, it was necessary to perform a series of pilot studies on homophones and the stimuli to be used in the experiments. These pilot studies are discussed next.

CHAPTER 3
PILOT STUDY 1: NORMATIVE STUDY OF HOMOPHONES

Word frequency is a critical issue in research on language and memory because a word's frequency can influence factors such as speed of access to a word's representation (e.g., a high-frequency word is accessed faster than a low-frequency word, Forster & Chambers, 1973). Although researchers have conducted normative studies of homophones' frequencies (Galbraith & Taschman, 1969; Kruez, 1987), no one has assessed potential differences in normative values between young and older adults. Rather, researchers using ambiguous words as a measure to compare processes and performance between young and older adults have referred to norms based on young adults' estimates (Davis, et al., 1990; Rose, et al., 1986). For example, Davis et al. (1990) and Rose et al. (1986) based homophone priming effects for young and older adults on frequency estimates for a pool of younger adults (Galbraith & Taschman, 1969). These studies assume that two cohorts separated by at least 40 years have identical frequency estimates for different meanings of ambiguous words, which is not necessarily true. Further, studies using frequency estimates overlook an important factor with homophones: homophone dominance. Homophone pairs often have one member that is more dominant than the other member, i.e., the dominant homophone is thought of first when the word is spoken. Although a homophone's dominance is often closely related to its frequency, sometimes two homophones can have similar frequencies while one homophone is thought of as the dominant one (e.g., *bale* and *bail* have frequencies of 5 and 6 words per million, respectively, but *bail* is considered dominant). Thus, studies involving homophones should consider homophone dominance because dominance may play a role in how quickly a homophone is accessed, similar to word frequency's role in word access.

Dominance is especially critical in studies using young and older adults because the two age groups might have different dominance estimates for homophones. For example, because older adults are more likely to be dealing with health and disease issues in later life, they might think of *genes* when they hear the phonology /jēnz/, whereas younger adults might think of *jeans* because *jeans* are an article of clothing often worn by younger generations. Although it may not be reasonable to "equate" young and older adults on dominance, researchers can control for it by using normative estimates.

To conduct the two experiments reported here, I not only needed estimates of homophone dominance by young and older adults, but I also needed to find a strong semantic associate for each homophone to use as the target word in the prime-target pairs. Thus, the purpose of this pilot study was twofold: (1) to determine a semantic associate for each homophone that has a strong association for both young and for older adults, and (2) to obtain ratings of homophone dominance from young and older adults so that only homophones that were agreed upon in terms of dominance were chosen for use in the experiments. First, participants completed the free association survey where they were asked to read ambiguous words and to respond to each word with the first word that came to mind (e.g., what is the first word that comes to mind when you read the word *beach?*). I wanted to find the strongest possible associate to each homophone (e.g., *sand* for *beach*) that young and older adults could agree upon so that potential age differences in results could not be attributed to poor stimuli selection. Second, participants completed the dominance survey where they were asked to circle the individual word within each homophone set that they considered to be dominant. Dominance was defined as the meaning they thought of first upon hearing the word (e.g., /bech/). Further instructions indicated that they might think about the sound of the word and which spelling/meaning comes to mind first. Because dominance was a variable in both experiments, I decided to use only those homophones that young and older adults equally agreed upon as dominant or subordinate.

Method

Participants. A total of 512 participants completed at least one of three surveys. Two hundred and twenty young adults between the ages of 17 and 25 (M = 19.56 years, SD = 1.53; 148 females, 72 males, with four participants not reporting ages) and 220 older adults between the ages of 62 and 91 (M = 73.58, SD = 6.81; 115 females, 104 males, 1 unknown, with seven participants not reporting ages) completed both the free association and written dominance surveys. An additional 36 young adults (17-24 years old, M = 19.78, SD = 1.69; 22 females, 14 males) and 36 older adults (56-83 years old, M = 71.92, SD = 7.55; 22 females, 14 males) participated in the auditory dominance survey. Young adults in both surveys were recruited from Introductory and Cognitive Psychology courses at the University of Florida and participated for extra credit or partial fulfillment of course credit. Older adults in both surveys were taken from the Cognition and Aging Lab Participant Pool, a pool that consists of older adults in the Gainesville community who were recruited from the University of Florida Alumni Association, local organizations, and churches.

Materials. Materials included three surveys: (1) written free association (WFA; Appendix A), (2) written dominance (WD; Appendix B), and (3) auditory dominance (AD). WFA included a list of 96 sets of homophones, including 91 homophone pairs and 5 homophone triplets, totaling 197 homophones (one homophone, *cite*, in the *site/sight/cite* triplet was inadvertently left off the WFA survey, thus making *sight/site* count as a pair instead of a triplet). Homophones were chosen from previous normative studies of homophones (Galbraith & Taschman, 1969; Kruez, 1987; Olson & Kausler, 1971). The words were randomly assigned a position (1-197) on the list, with the stipulation that homophones within a set (e.g., *beach/beech*) were separated by at least 10 other words. Two survey forms were constructed such that one-half of the forms listed one member of a homophone set first and the other half of the forms listed the other member of the homophone set first.

WD included the same 96 sets (pairs and triplets) of homophones as WFA: 90 sets consisted of two homophone words (e.g., *beach, beech*) and six sets included three homophone words (e.g., *write, right, rite*) (note that in WD *cite* was included in the homophone set *site/sight/cite*, making this set a triplet). Homophones within a set were typed on the same line and sets were randomly assigned a position (1-96) on the list. In order to avoid ordering effects of homophones within a set, two lists were made such that one member of each homophone set came first one half of the time and the other member came first the other half of the time (for sets with three homophones, two different orderings of the three words were made). The word "equal" was typed next to each homophone set to give participants the option of choosing "equal" if they thought that homophones in a set were equal in dominance (i.e., there was no obvious choice for dominant and subordinate).

Auditory Dominance included the same 96 sets of homophones as WFA and WD, and had the same counterbalanced ordering as WD.

Procedure. Adults participating in the written surveys completed WFA and then WD. Each survey was preceded by a separate set of instructions. The instructions for WFA told participants that they would see a list of words and that each word would have a blank next to it. Participants were to read and respond to each word with the first word that came to mind. Participants were also instructed to write "no response" if a response did not immediately and automatically come to mind. On average, a homophone was responded to 213.9 times for older adults and 203.4 times for young adults. Two examples that were not included in the test list were provided in the instructions. Prior to responding to the first word, participants were asked to write down the time in a "start time" blank, and immediately after the last word participants were instructed to write down the time in a "stop time" blank. Requests for time were included in order to ensure that participants did not spend too much time on the task, as they were instructed to respond to the homophones with the first word that came to mind. The time range for young adults was 5 to 30 minutes (M = 14 minutes, SD = 4 minutes, with 20 participants not reporting

times and one participant being excluded from mean times for not completing one page of the survey). Older adults spent between 10 and 55 minutes completing the WFA (M = 23 minutes, SD = 9 minutes, with 5 participants not reporting times).

After the WFA, participants read instructions for WD. The instructions defined "homophone" and gave participants an example of a homophone pair that was not included in the survey (*sale, sail*). Participants were told that they would see a list of homophone pairs and triplets and that they were to choose the individual word that they felt to be more dominant in the English language. The following definition was given for dominance: "The dominant word in each pair corresponds to the meaning you think of first upon hearing the word; you might think about the sound of the word and which spelling/meaning comes to mind first. It might be a word that you encounter often in reading, talking, watching television, or listening to the radio." The word "equal" was included in each homophone set and participants were instructed to circle "equal" in cases where they considered both words to be equally dominant. One example was included to orient participants to the task prior to beginning the survey. A blank was provided at the top and bottom of the list for participants to write their "start time" and "stop time," indicating when they began and ended the task. Young adults reported completing the WD survey in a range of 1 to 14 minutes (M = 4 minutes, SD = 2 minutes, with 22 participants not reporting times and one participant being excluded from mean times for only completing one-half of the survey). Older adults reported spending between 3 and 30 minutes completing the WD survey (M = 8 minutes, SD = 4 minutes, with 24 participants not reporting times).

The AD survey was completed by a different set of participants. Verbal instructions asked participants to write down the spelling of the first word that came to mind when they heard each word read aloud. The phonology for each homophone set (e.g., /bēch/ for *beach/beech*) was read aloud to participants. Four older adults were individually tested in the laboratory and 32 older adults were individually tested over the phone. Phone testing required older adults to write the spelling on a sheet of paper then read their spelling to the experimenter. All young adults

were tested either individually or in groups of 2-10 and wrote their spelling on an answer sheet numbered 1-96. Start and stop times were also collected in this task. Young adults completed the survey in 7 to 29 minutes (M = 13 minutes, SD = 6 minutes). Older adults took between 7 and 26 minutes to complete the survey (M = 11 minutes, SD = 3 minutes). Young adults' times might be slightly misleading because many of them were tested in groups where they had to wait on everyone to finish spelling a homophone in order to proceed to the next homophone. In contrast, older adults were tested individually and could proceed at their own pace.

Free Association Results: Choosing Target Associates from Homophone Norms

The goal of collecting the homophone free association norms was to find a "target associate" for each homophone that was given by both young and older adults (for use in Experiment 1). To choose a target associate, each age group's top six most frequently given responses in WFA were compared for similarities (e.g., young adults' most frequently given response was compared to older adults' most frequently given response). When possible, the most frequently reported response by both young and older adults was chosen as the target associate (see below for problems that arose when choosing targets). If the most frequently given associate by young and older adults did not match (e.g., young adults gave *wine* for *cellar*, whereas older adults gave *basement*), a response was chosen that was frequently reported for both age groups with approximately half of these responses being more frequent for young and approximately half being more frequent for older adults. Across all targets, young adults gave the target in the free association survey 26.4% (SD = 20.80%) of the time and older adults gave the target 28.6% (SD = 22.42%) of the time.

When choosing target associates, a number of methodological difficulties arose. First, I did not want to choose an associate that had the same first letter as the homophone itself because participants might be encouraged to produce the homophone (e.g., *sign-sine*) instead of the associate (e.g., *sign-stop*). To solve this difficulty, I only used same-letter associates when there

was no other possible (good) associate or when the associate was so good that we did not want to use another (e.g., *him-her*). Only two homophones were paired with a semantic associate that began with the same first letter (*him-her* and *graze-grass*, 1.8% of the total stimuli).

Second, many associates proposed a potential difficulty for the phonological condition: I did not want to choose an associate (e.g., *tree* for *beech*) that had a first letter (e.g., *t*) that corresponded to a semantic associate (e.g., *towel*) of the opposite homophone (e.g., *beach*). I was concerned that a semantic relationship such as this would elicit a semantic response in the phonological condition, e.g., the strong association between *beach* and *towel* would reduce the likelihood of phonological priming between *beach* and *tree*. To screen for this problem in advance, the associates were pretested in the semantic and phonological conditions (see Pilot Study 2 for description of Free Association to Stems pilot study). Although this problem was nearly impossible to completely eliminate, as there can be some association formed between most words and a stem, we attempted to minimize the problem with pretesting.

Third, I did not want to use a target association more than once. Along with a few others, this problem specifically affected homophones who had *look* as their strongest associate, e.g., *peer, browse, stare*. In these cases, less desirable target associates (e.g., *stare-at*) were chosen for all but one of the homophones that had similar target associates. Eight target words fell into this category (7.5% of the total stimuli). However, two sets of primes were inadvertently paired with the same target word: *pried* and *gate* were paired with *open,* and *peer* and *browse* were paired with *look*.

Fourth, I tried to avoid choosing a letter that corresponded to more than one associate, e.g., *bread* and *boy* for *dough*. This problem was addressed through pretesting measures in Pilot Study 2, similar to the second problem mentioned previously. However, sometimes multiple targets were accepted because a single (strong) target associate could not be found (e.g., the free association data indicated that the best associate for *hymn* was *church*, but pilot testing indicated

that people responded with a variety of c-related words, such as *choir, chorus,* and *carol*). Multiple targets were accepted for 19 homophones (see Table C-1).

Finally, I tried to minimize the total number of associates that started with the same first letter. In order to minimize the chance of repetition priming (i.e., repeatedly using the same word as a response), no more than ten associates in the total list started with the same letter. Further, filler (non-homophone) words were paired with letters that were not used frequently as targets so that commonly used letters would not be repeated more than ten times throughout the list.

Dominance Results: Determining Homophone Dominance from Homophone Norms

Determining dominance was slightly tricky because responses from both written and auditory surveys were assessed. Ideally, only auditory dominance would have been tested because hearing the homophone allows for more ambiguity than seeing a homophone spelled out on paper. Because only the phonology is heard and participants are asked to write the first spelling that comes to mind, auditory presentation is likely a more "pure" way to measure homophone dominance. However, logistical reasons kept me from only assessing dominance auditorily: normative data requires a large sample of participants and bringing over 200 older adults into the laboratory would have been too time consuming and expensive. Thus, a written survey was mailed to the older adults and was completed by young adults in large groups on campus. However, as a "check" on the written dominance data, a smaller number of participants (36 of each age group) performed the auditory dominance survey. In most cases, auditory and written dominance results agreed with one another, as is discussed next.

Because having both surveys to take into account provided an extra difficulty, I developed four "rules," or categories, of dominance. The best scenario, or rule, for determining which homophone in a pair was dominant and which was subordinate was when young and older adults agreed on the dominant word of each pair in both the auditory and written dominance surveys. Further, this rule required that at least 60% of the age group chose one word as the

dominant one on both written and auditory surveys. This rule applied to the majority of the homophone pairs (60%) that were included in the experiments.

For cases where the above rule did not apply, a "next best" case scenario was used: Young and older adults agreed on the dominant word on both the auditory and written surveys, but one word might not have been chosen as dominant 60% of the time on either the auditory or written survey. Often the less than 60% would occur with the written survey because there was a chance to circle "equal," whereas with the auditory survey a choice of which spelling to produce eliminated this problem. In this "next best" case, at least a 25% separation remained between the two words in the survey where one word was not chosen as dominant 60% of the time (i.e., one word was voted as dominant 25% more often than the other word in a pair). This rule applied to 13% of the homophone pairs that were used in the experiments.

The third best scenario included cases where there was not at least a 25% separation between the dominance of the two homophones (as in the above, second-best scenario), for either the auditory or written surveys (except in one case where *both* surveys did not have the 25% separation). In these cases I looked for a trend (e.g., one homophone was rated as dominant 10% more often than the other) in both surveys towards one homophone being more dominant. I did not use pairs that were judged to have homophones of equal dominance; rather, I always looked for a preferably strong trend towards dominance in at least the written or auditory survey, with at least a small trend in the other survey. This rule applied to 21% of the homophone pairs that were used in the experiments.

Finally, the least ideal cases were those when the dominance reported on the auditory and written surveys did not match. In these cases, only those pairs that young and old showed identical patterns on were used (i.e., the young adult's auditory and written agreed with the older adults, even though the dominance was in one direction for auditory and the other direction for written). In these cases, where the auditory and written surveys mismatched, the results of the written survey were followed because it not only had more participants to draw from, but there is

evidence (Davis et al., 1990) that when spelling unprimed homophones (as in the auditory survey), older adults tend to spell the lower-frequency alternative more often than young adults. Thus, it is unclear if auditory tests truly tap into dominance for older adults because of their tendency to produce the low-frequency alternative. This rule applied to 6% of the homophone pairs that were chosen for the experiments.

CHAPTER 4
PILOT STUDY 2: FREE ASSOCIATION TO STEMS PILOT

A pilot study using the results of the normative surveys was conducted for two purposes. First, because some of the options for target associates were not ideal (e.g., I could not use a homophone's most frequently given associate because of one of the restrictions discussed previously), I felt that it was necessary to pilot test homophones and targets in the semantic (e.g., *beech-nut*) condition. I wanted to pilot test homophones and their targets to make sure that the target was strong enough to elicit semantic priming (e.g., would *stare-a*____ elicit the response "*at*" even though it was not the most frequently given response in the free association survey?). Even though some target associates were not the most frequently given response in the free association survey, the constraint of pairing their first letter with the homophone might increase the likelihood of responding with that associate (e.g., when not given the option of responding with *look* due to the stem "*a*____," will people respond with *at* instead?). In a similar regard, if the target associate was <u>not</u> frequently given as a response in the semantic condition, then that associate was probably not strongly connected to the homophone and therefore that associate would not likely be given as a response in the phonological condition. Based on results from similar studies using word recognition, the effect size in the phonological condition was expected to be small; therefore, it was important to increase the chance of finding an effect by having the strongest semantic association as possible. For those homophone-target pairs in the semantic condition that did not elicit a strong target response, a different target word was chosen and pilot tested in a second round of testing and the strongest associate was chosen to use as the target in Experiment 1.

The second purpose for this pilot study was to test target associates in the phonological (e.g., *beech-sand*) condition. I was concerned that some of the target associates might have first letters that could elicit a semantic response in the phonological condition, overriding the chance for phonological priming. For example, *girl* was tested as the target associate of *belle* in the semantic condition. The resulting phonological condition was *bell-g____*, to which many people responded *gong*, an obvious semantic associate of *bell*. In this case, the semantic connection between *bell* and *gong* was strong enough to override any phonological priming that might have occurred between *bell* and *girl*. As this example illustrates, pilot testing of potential target associates in the phonological condition was important prior to conducting Experiment 1.

<u>Method</u>

<u>Participants.</u> A total of 83 young adults participated in the pilot study: 54 participants (18-30 years of age, <u>M</u> = 19.26 years, <u>SD</u> = 2.16, 44 females, 10 males, with one female participant not reporting her age) took part in the testing of one set of stimuli and an additional 29 participants (18-21 years of age, <u>M</u> = 18.34 years, <u>SD</u> = 0.67, 26 females, 3 males) took part in the testing of a second set of stimuli. Two participants who took part in the first testing session were excluded from analyses for not following directions or not finishing at least one-half of the stimuli list, leaving 52 participants. Both groups of young adults were students in Introductory or Cognitive Psychology courses. After pilot testing with young adults, the list of stimuli was narrowed and just one group of older adults completed a more finalized list. Thirty older adults (59-86 years of age, <u>M</u> = 74.23 years, <u>SD</u> = 7.04, 17 females, 13 males) from the Cognition and Aging Lab Participant Pool completed and returned the mail survey.

<u>Materials.</u> Two sets of stimuli were tested with young adults because some target words in the first set were problematic and new targets needed to be tested in the second set (e.g., a target in the semantic condition was rarely given as a response or there was a semantic alternative given in the phonological condition). After testing with young adults, a third set of stimuli (which included some stimuli from sets 1 and 2) was put together to test with older adults.

For stimuli set 1, four lists were developed, where each list included a total of 114 word-stem pairs (including 76 homophones and 38 filler words). Twenty of the 96 homophone sets from the norming study could not be included because the dominance survey results indicated that two members of a set could not be distinguished as dominant and subordinate (i.e., either young and older adults did not agree on dominance, or the members of a homophone set were rated as equally dominant). Stimuli were tested in two conditions: (1) semantic, where a homophone was paired with a target (semantic) associate taken from the free association survey (e.g., *beach-sand*; *beech-nut*) and (2) phonological, where one member of a homophone pair was paired with the associate of the other member (*beach-nut*; *beech-sand*). Four different stimuli sets were developed to ensure that participants did not encounter more than one member of a homophone pair in more than one condition. For example, the homophone pair *beach/beech* was tested in four groups: (1) *beach-s____* (*sand*; semantic), (2) *beech-n____* (*nut*; semantic), (3) *beach-n____* (*nut*; phonological), and (4) *beech-s____* (*sand*; phonological). Further, filler words were included in order to minimize awareness of homophones in the list. These fillers were not homophones and were paired with one-letter stems that were not frequently used as stems with the homophones. Fillers were placed after every two homophones. Lists were counterbalanced so that half of the homophone stimuli in each list included semantic conditions and half included phonological conditions.

Stimuli set 2 was similar to stimuli set 1 except that each participant completed one of four lists of 76 word-stem pairs (including 48 homophones and 28 fillers). Set 2 included homophones from set 1 that either (1) did not produce strong semantic responses in the semantic condition (e.g., *girl* was not given frequently as a response to *belle-g____*), or (2) too often produced a semantic response in the phonological condition (e.g., *gong* was given too frequently for *bell-g___*). Thus, each homophone that was included in set 2 was paired with a different one-letter stem than it was paired with in set 1.

After settling on a set of best stimuli from the young adult data, 68 of the 76 homophone pairs were chosen for testing with older adults; thus, a total of 136 stimuli (68 pairs with two members in each pair) were paired with target words. This stimulus set (set 3) included homophones and target associates from sets 1 and 2. Twenty of the 136 stimuli were tested with two targets because the two potential targets were both strong or fairly strong associates for young adults (e.g., *vase* and *ashes* were both strong associates of *urn*). Having two possible associates to test with older adults allowed for a second option in case one associate was not strong for older adults. Four lists of 117 word-stem pairs were developed to test with older adults. Each list included 78 homophones and 39 fillers; ten homophones had to be repeated on each list in order to test for the additional target words. However, the same homophone (e.g., *urn*) was never tested twice in one list; instead, both members of a homophone (e.g., *urn, earn*) were included on a list and were always paired with different one-letter stems (*earn-m*___ and *urn-v*___).

Results of the Free Association to Stems Pilot Study

The goal of this pilot study was to see if the target words that I had chosen from the norming survey were elicited when primed (paired) with their corresponding homophone. As noted earlier, stimuli constraints sometimes kept me from choosing the best target associate from the norming survey. However, I maintained that pairing a homophone with the one-letter stem of the target would constrain people's responses (to words beginning with that letter). Thus, in this pilot study I expected to see an increase in the percent of time people gave the target word as a response relative to the percent of time that target was given when simply asked to free associate, as in the norming survey (e.g., when people are given *stare-a*___, it is likely that the response "*at*" will be given more often than when asked to simply free associate to *stare*, as in the free association norming survey when the most commonly given response was "*look*").

Table C-1 contains the final list of stimuli included in Experiment 1, along with each homophone's target word, the percent of time young and older adults gave the target word as a

response in Pilot Study 2, and an orthographic control word to be discussed in Experiment 1. The majority of targets (86% for young adults and 90% for older adults) were given as a response at least 30% of the time. Further, across all targets, young adults gave the target as a response 57.35% (SD = 20.93%) of the time and older adults gave the target 62.71% (SD = 22.33%) of the time. These mean percentages are a large increase over those from the free association survey (26.4% for young adults and 28.6% for older adults; see norming results for more detail).

CHAPTER 5
EXPERIMENT 1: PHONOLOGICAL PRIMING OF PREEXISTING ASSOCIATIONS

The purpose of Experiment 1 was to assess phonological priming across preexisting associations in young and elderly adults. According to NST, connections between preexisting associations should be strong because they have been frequently activated across the life span. Thus, the connections between *beach* and *sand* (a semantic connection) and between *beach* and *beech* (a phonological connection) should be strong because these words have been paired across time and because activation of one of the words spreads node priming to the other word. Previous experiments with young adults showed phonological priming between words and homophones of their semantic associates (e.g., between *beech* and *sand*) in a word recognition paradigm (Lesch & Pollatsek, 1993; Lukatela & Turvey, 1994), which used response time measures to determine whether priming occurred. For example, if participants responded more quickly to *sand* preceded by *beech* than they did to *sand* preceded by an unrelated word (e.g., *batch)*, we assume that word recognition contains a phonological component. However, whether phonological priming involving semantic associates would occur in a word <u>retrieval</u> paradigm was unknown, in addition to whether it would occur in older adults.

The present experiment investigated phonological priming of preexisting connections by having participants perform a speeded word-stem completion on word stems that were paired with a semantic, phonological, or unrelated word. Thus, this experiment incorporated three conditions that represented the prime-target relationship: (1) a <u>semantic</u> condition where a homophone word was paired with the one-letter stem of a semantic associate (e.g., *beach-s____*), (2) a <u>phonological</u> condition where a word was paired with the stem of a semantic associate of the word's homophone (e.g., *beech-s____*), and (3) an <u>unrelated</u> condition where a word that was

orthographically similar to the homophones was paired with the same stem used in the other two conditions (e.g., *batch-s*_____). The homophone, or prime word, was manipulated in order to measure its effect on the associate, or target stem (e.g., *sand*), which remained constant in all the word pairs.

In addition to semantic and phonological manipulations of homophones and their target associates, I chose to manipulate homophone dominance. There were three reasons for manipulating dominance. First, dominance is inherent in most homophone pairs, for the majority of them have a dominant and subordinate member (with other homophones having equal dominance, such as *mail* and *male*); thus, researchers using homophones should not ignore this fundamental variable. The second reason for manipulating dominance was to see if there are any differences in phonological priming between dominant and subordinate homophones. Previous studies that investigated phonological priming in recognition paradigms (Lesch & Pollatsek, 1993) did not manipulate dominance and therefore cannot make any conclusions about whether phonological priming might be stronger for dominant or for subordinate homophones (although Lukatela & Turvey (1994) manipulated frequency; related predictions are discussed in the predictions section below). The third reason I was interested in homophone dominance was to see if there were any age differences in the amount of semantic priming between dominant and subordinate homophones. In general, older adults exhibit larger semantic priming effects (Laver & Burke, 1993), although no one has investigated the effect of dominance on semantic priming.

The magnitude of priming was measured through implicit tests of word-stem completion and response time to complete the stem. In general, implicit tests are thought to measure unconscious memory processes and are commonly used to measure priming effects. Priming can be observed to the extent that participants complete the stem with the target word more often after recent exposure than after no exposure. Response time to complete the stem allowed for assessment of how quickly participants retrieve words when presented with a semantic,

phonological, or unrelated prime word. To my knowledge, the use of response time to study stem completions is novel in this study; previous studies only measured the response (word) given to complete the stem. In general, older adults do not demonstrate significant deficits on implicit tasks, especially ones involving preexisting associations, although they show significant declines on explicit tests that require conscious recall (e.g., older adults often show equivalent repetition priming effects with young adults, but older adults have more difficulty when asked to overtly recall a word list presented earlier). However, as noted previously, comparisons of implicit tests in older adults have come under recent scrutiny (Fleischman & Gabrieli, 1998; Light, et al., 2000).

Predictions

The primary predicted effect was a Prime-Target Relationship (semantic, phonological) x Dominance (dominant, subordinate) interaction, such that significant priming was expected both in the semantic and phonological conditions, with greater semantic than phonological priming (priming is measured here by subtracting the unrelated condition mean from each of the primed condition means). However, theories such as NST and past research such as that of Lukatela and Turvey (1994) and Gottlob et al. (1999) predict an interaction with dominance: dominance of the homophone should be critical in the phonological condition but not the semantic condition (see Figure 1-1).

According to NST, in order for priming to occur in the phonological condition, the other spelling of the homophone must get primed, and this priming should happen differentially for dominant and subordinate homophones. When the subordinate homophone is presented (e.g., *beech-s____*), activation of the dominant homophone (*beach*) is likely to occur because the phonological node /bēch/ is more strongly connected to the dominant homophone, due to greater frequency of use. This activation will enable retrieval of a semantically related word *(sand)* because of the strong semantic connection between *beach* and *sand* and the restricted number of

word choices that begin with the given letter, "*s*." In contrast, when the dominant homophone is presented (e.g., *beach-n*____), activation of the subordinate homophone (*beech*) is less likely (but still possible) because the phonological nodes are more strongly connected to the dominant homophone, which also happens to be the presented word. Therefore, if the subordinate homophone is not activated, then its semantic associate, *nut,* is not likely to be retrieved.

Indeed, Lukatela and Turvey (1994) found more phonological priming of semantic associates in word <u>recognition</u> at longer presentation intervals (250 ms) for low-frequency homophones than high-frequency ones. Low-frequency words take longer to activate than high-frequency words and therefore orthography's influence on activation is slower for low-frequency words (Van Orden's (1987) "verification process" where the written spelling is checked with the spelling that is stored in memory was described previously). Assuming that the low-frequency homophones are also subordinate homophones, Lukatela and Turvey's predictions are similar to NST's. However, Lukatela and Turvey's recognition priming paradigm was very short-term (within 250 ms), whereas my retrieval paradigm occurs across longer periods (within 4 seconds). At those longer intervals, Lukatela and Turvey might suggest that orthographic constraints would influence even low-frequency homophones, and no dominance effect would appear.

In addition to the predictions of NST, research by Gottlob et al. (1999) that was used to explain the role of dominance in homographs (e.g., *wind*) and homonyms (e.g., *spring*) can be extended to homophones. Gottlob and colleagues' (1999) Experiment 2 on semantic priming between homographs and their associates and between homonyms and their associates found that participants were faster to say that an associate was related to a prime word if the associate was related to the dominant (rather than subordinate) meaning of the homograph or homonym. However, the dominance effect was less pronounced for homonyms because homonyms share the same pronunciation and therefore phonology cannot help access the dominant meaning as it can with homographs. Gottlob et al. explain their results in terms of the dynamics between

orthography (O), phonology (P), and semantics (S) (see Van Orden & Goldinger, 1994 for details about their phonological coherence hypothesis). In order for word recognition to occur, O-P dynamics must first stabilize (i.e., come to some agreement) to allow higher order semantic processing. Because homographs and homonyms share orthography, Gottlob et al. were able to investigate the dynamics between phonology and semantics. They found that meaning dominance plays a large role in word recognition for words that share orthography but differ in pronunciation and semantics (homographs), and play a smaller but nonetheless significant role in word recognition for words that share orthography and phonology but differ in semantics (homonyms). Gottlob et al. did not speculate about homophones, which differ in orthography and semantics, but share one pronunciation.

One interpretation of Gottlob and colleagues' results is that orthographic and phonological dynamics will stabilize faster for dominant homophones than subordinate homophones because dominant homophones are activated more often (see also Strain, Patterson, & Seidenberg, 1995). Therefore, the O-P dynamics for dominant homophones stabilize faster than the O-P dynamics for subordinate homophones. Given this assumption, predictions can be made for the phonological priming of a homophone's semantic associates. If a dominant homophone's (*beach*) O-P dynamics stabilize quickly, semantic processing of the appropriate associates (*sand, water*) can quickly occur, and therefore the semantic associate (*nut*) of the subordinate homophone (*beech*) will be less likely to be activated. In contrast, a subordinate homophone's O-P dynamics should take longer to stabilize and therefore phonological priming of semantic associates is likely to occur prior to stabilization. These predictions are consistent with those of NST and Lukatela and Turvey (1994). Also similar to Lukatela and Turvey, however, is the time course of stabilization: Gottlob et al. might suggests no dominance effect because of the longer time interval required by retrieval, i.e., even subordinate homophone O-P dynamics might stabilize across the four seconds that participants are given to respond to the word stems.

In contrast to the phonological condition, NST predicts that the semantic condition should show equivalent priming for both dominant and subordinate homophones because presentation of the word (e.g., *beach* or *beech*) immediately primes semantically related words (e.g., *sand* or *nut*), which are strongly connected and override the need for utilizing the phonological connections (note that other theories discussed in regards to phonological priming do not make predictions for semantic priming). Further, greater semantic priming was expected for older adults than young adults, a finding often reported in recognition priming studies (Laver & Burke, 1993). Because this experiment required access of preexisting associations, NST predicted that young and older adults would differ in semantic priming (such that older adults would show more semantic priming), but would demonstrate equivalent magnitudes of phonological priming.

In contrast to the aging predictions made by NST, the Inhibition Deficit hypothesis (IDH; Hasher & Zacks, 1988) predicts that older adults should show more phonological priming than young adults because older adults should be unable to inhibit the unrelated associate (e.g., *nut*) of the homophone (e.g., *beach*). In contrast, IDH predicts that older adults should have smaller semantic priming effects than young adults because older adults are unable to inhibit unrelated words and therefore the spread of activation to semantically related words would be limited (see also, Burke, 1997).

Method

Participants. Young participants (ages 17-26; $\underline{M} = 18.73$, $\underline{SD} = 1.38$) included 60 students from the University of Florida who were enrolled in General Psychology or Cognitive Psychology courses. Young adults received partial course credit or extra credit for one-half hour of participation. Sixty older adults (ages 60-86; $\underline{M} = 72.87$, $\underline{SD} = 6.98$) were recruited from the University of Florida Cognition and Aging Lab Participant Pool.

Both age groups completed the following background information forms/tests: (1) a participant questionnaire asking for age, education, ethnicity, native language, health status, and current medications (Appendix D), (2) the Nelson-Denny test, a 25-item vocabulary test, and (3) forward and backward digit span tests to assess working memory (Appendix E). Older adults were also given the Mini Mental State Examination (MMSE) to assess any cognitive impairment and/or dementia. Mean scores on these tests for each age group can be found in Table 5-1. Scores are based on the 55 participants in each age group that were included in analyses (five participants in each age group were excluded from analyses for not following directions on the word-stem completion task). Young adults included 40 females and 15 males, and older adults included 24 females and 31 males. Independent samples t-tests indicated that young adults had less years of education, $\underline{t}(108) = -12.35$, $\underline{p} < .001$, and worse vocabularies, $\underline{t}(108) = -12.09$, $\underline{p} < .001$ than older adults, but larger forward, $\underline{t}(107) = 2.21$, $\underline{p} < .029$, and backward, $\underline{t}(107) = 3.27$, $\underline{p} < .001$, digit spans. Young and older adults did not differ on self-reported health, $\underline{p} > .46$.

Design. The experimental design consisted of three factors, with Age (young, older adults) as the only between-participants factor, and Dominance of the prime (dominant, subordinate) and Prime-Target Relationship (semantic, phonological, unrelated) as within-participants factors. The primary dependent variables were the proportion of word stems completed with the target word, and the response time calculated as the difference between the stem onset and the voice response.

Apparatus. The experiment was performed on Pentium II 350 MHz IBM-compatible computers using a program written in Visual Basic. The microphone used to record response times was the Cyber Acoustics Desktop Standing Microphone.

Materials. This experiment utilized the association norms described in the pilot studies. To summarize those pilot studies briefly, young and older adults performed free association to a list of 197 homophones, and then chose which word of a homophone pair they believed to be more dominant. These norms were used (1) to choose an associate (e.g., *sand* for *beach*) that was

provided by both young and older adults, and (2) to assess dominance within each homophone pair. Attempts were made to choose homophone pairs that produced equivalent associations and dominance ratings for young and older adults. Forty-eight homophone pairs were chosen to use in the experiment (these pairs had the most equivalent free associations and dominance ratings for young and older adults; see Table C-1). Each of these 48 homophone pairs had two target words (associates) assigned to it: One target word was chosen for the dominant homophone (e.g., *sand* for *beach*) and one target was chosen for the subordinate homophone (e.g., *nut* for *beech*). The target words were then counterbalanced across the three main prime-target relationships (semantic, phonological, unrelated) for a total of 6 versions. For example, the target word *sand* fell in one of three versions: (1) semantic-dominant, *beach-sand*; (2) phonological-subordinate, *beech-sand*; and (3) unrelated, *batch-sand*. Similarly, the target word *nut* fell in one of three versions: (1) semantic-subordinate, *beech-nut*; (2) phonological-dominant, *beach-nut*; and (3) unrelated, *batch-nut*. The dominant and subordinate word stems were counterbalanced across participants so that half of the stems consisted of the dominant homophone for any given pair (e.g., *beach-sand*) and the other half consisted of the subordinate homophone (e.g., *byte-giga*).

In addition to the 48 homophone pairs, 10 "foil" homophones were included for pilot testing for a future experiment. These foils only included one member of a homophone pair (e.g., *bell* but not *belle*) due to problems finding a good semantic associate with the other member (e.g., young and older adults did not agree on a semantic associate; see Table C-2 for a list of foils). Because the foils included only one member of a homophone pair, they were matched to only three versions; for example, the homophone *bell* was included in the following versions: (1) semantic-dominate, *bell-ring*; (2) phonological-subordinate, *belle-ring*; and (3) unrelated, *belt-ring*. As with the regular 48 homophone pairs, the target word remained the same in the three conditions for each foil homophone. Foils were not counterbalanced with the regular 48 homophone pairs; instead, five foils were included in each version.

Each homophone pair was assigned one unrelated, orthographically-similar control word to serve in the "prime" position (e.g., *batch* for *beach/beech*). I chose words that were similar in spelling and length (and frequency where possible) to either the dominant or the subordinate homophone (29 unrelated words favored the dominant homophone and 29 favored the subordinate homophone). I always chose words that started with the same letter as the homophones they were paired with (either dominant or subordinate). In addition, attempts were made to have multiple letters overlap and to have word length similar. The average word length for the homophones that were matched with orthographic control words was 4.38 (4.42 for the 29 dominant homophones and 4.34 for the 29 subordinate homophones). The average word length for the orthographic control words was 4.43 (4.48 for the control words matched to the dominant homophones and 4.38 for the control words matched to the subordinate homophones). Finally, I matched the homophones and their orthographic control words as much as possible on overall word frequency without sacrificing spelling similarity. Across the homophones that were matched with an orthographic control, the average Kucera and Francis (1967) frequency was 119.86 (excluding one outlier with a frequency over 20,000, *in*); the average Kucera and Francis frequency was 139.22 for orthographic control words. The 29 dominant homophones had an average frequency of 213.21 (excluding *in*) and their matched control words had an average frequency of 252.52. The 29 subordinate homophones had an average frequency of 29.72 and their matched control words had an average frequency of 25.93. Thus, the frequencies of the orthographic control words were closely matched to their corresponding dominant or subordinate homophone.

Overall, the 58 subordinate homophones had a mean Kucera and Francis (1967) and frequency of 20.69, whereas the 58 dominant homophones had a mean frequency of 185.37 (excluding one outlier with a frequency over 20,000, *in*).

In summary, a total of 90 word-stems were presented to each participant: 5 practice trials with unrelated (nonhomophone) paired word-stems, and 85 experimental trials including: 8 word

stems from each of the six versions (8 semantic-dominant, 8 semantic-subordinate, 8 phonological-dominant, 8 phonological-subordinate, 8 unrelated paired with the dominant homophone's target word, and 8 unrelated paired with the subordinate homophone's target word), 5 foils, and 32 unrelated (nonhomophone) word stems (i.e., fillers) intended to disguise the nature of the study.

Upon completion of the experiment, participants were verbally administered a background questionnaire intended to assess any knowledge they had of the relationship between prime and target words, and to see if they responded to the homophone trials any differently than they did to the non-homophone trials (see Appendix F).

Procedure. Participants completed the background information paperwork and tests at the beginning of the testing session. Paperwork and verbally-presented tests (digit span, MMSE) took approximately 10-15 minutes to complete.

Before starting the experiment, participants read written instructions that were then reiterated verbally by the experimenter. In general, participants were instructed to read the word and stem to themselves (silently) and to complete the stem aloud with the first word that came to mind and started with the given letter. Participants were instructed to say their response out loud so the computer could track the time it took them to respond. Participants were instructed to press the "Enter" key to start the first trial; similarly, participants controlled the pace of the entire experiment by pressing the "Enter" key after one trial was completed and they were ready for the next trial. At the onset of each trial, participants saw a warning signal (+) presented for 500 ms, followed by the paired word-stem that remained visible until a verbal response was made or 4000 ms had elapsed. Onset of the verbal response was recorded by the computer and served as a measure of response time. This speeded verbal response was intended to encourage participants to give the first word that came to mind, and allowed for a more sensitive measurement of implicit memory than a written response. If participants did not respond in the time allotted, the word stem disappeared, no response time was recorded, and a new screen appeared that instructed

participants to press the "Enter" key to begin the next trial. The experimenter wrote down each response given by the participant. The experiment took approximately 10-15 minutes. After completion of the experiment, participants were given the post-experiment questionnaire and were then debriefed.

Results

For all analyses, "foil" homophones were excluded because they did not include both members of a homophone pair and were not counterbalanced across all six versions; thus, analyses were completed on 48 homophone pairs. Five young adults and 5 older adults were also excluded because of failure to follow directions. Table 5-2 displays the means and standard deviations for the percent of time a word stem was completed with the target word for young and older adults.

Target Completion. A 2 (age: young, older) x 2 (prime-target relationship: semantic, phonological) x 2 (dominance: dominant, subordinate) analysis of variance (ANOVA) using participants (F1) and items (F2) as units of measure was performed on the percent of time participants completed the stem with the target word. The unrelated condition is not included in this ANOVA because it cannot be broken into dominant and subordinate; however, analyses subtracting the unrelated condition from the semantic and phonological conditions (a difference measure) are reported subsequently. An independent samples t-test revealed no age difference in the unrelated condition, $t1(108) = -.163$, $p > .871$, $t2(96) = .00$, $p > .99$, suggesting young and older adults had similar completion with the target word in the unrelated condition. The Age x Prime-Target Relationship x Dominance ANOVA revealed main effects for Age, $F1\ (1, 108) = 5.47$, $MSE = .06$, $p < .021$, $F2\ (1, 94) = 18.31$, $MSE = .02$, $p < .001$, and Prime-Target Relationship, $F1\ (1, 108) = 245.92$, $MSE = .05$, $p < .001$, $F2\ (1, 94) = 182.21$, $MSE = .06$, $p < .001$, but not for Dominance, $F1\ (1, 108) = 1{,}46$, $MSE = .02$, $p > .23$, $F2 < 1$. Two-way interactions were found for Age x Prime-Target Relationship, $F1\ (1, 108) = 12.12$, $MSE = .05$, p

< .001, $F2$ (1, 94) = 41.60, MSE = .01, p < .001, and for Prime-Target Relationship x Dominance in the participant analysis, $F1$ (1, 108) = 9.68, MSE = .02, p < .002, but not in the item analysis, $F2$ (1, 94) = 2.27, MSE = .06, p > .135. No Age x Dominance interaction was found in either analysis, $F1$ (1, 108) = 2.47, MSE = .02, p > .119, $F2$ (1, 94) = 2.23, MSE = .02, p > .139. These main effects and two-way interactions were mediated by a significant interaction between Age, Prime-Target Relationship, and Dominance, $F1$ (1, 108) = 6.44, MSE = .02, p < .013, $F2$ (1, 94) = 10.03, MSE = .01, p < .002.

Following up the three-way interaction revealed a significant Prime-Target Relationship x Dominance interaction for young adults, $F1$ (1, 108) = 15.95, MSE = .02, p < .001, $F2$ (1, 94) = 7.72, MSE = .04, p < .007. The participant analysis revealed that young adults had greater completion with the target word for dominant homophones than subordinate homophones in the semantic condition ($p1$ < .014), although the item analysis was marginally significant and showed the same pattern ($p2$ > .089). In contrast, young adults had greater target word completion for subordinate homophones than dominant homophones in the phonological condition ($p1$ < .001, $p2$ < .017).

Unlike the young adults, the older adults did not have a significant Prime-Target Relationship x Dominance interaction, $F1$ < 1, $F2$ < 1. However, older adults had a significant main effect of Prime-Target Relationship ($F1$ (1, 108) = 183.61, MSE = .05, p < .001; $F2$ (1, 94) = 222.41, MSE = .04, p < .001), such that older adults had greater target word completion in the semantic than phonological condition. The main effect of Dominance was significant in the participant analysis only, $F1$ (1, 108) = 3.86, MSE = .02, p < .05; $F2$ (1, 94) = 1.16, MSE = .04, p > .285, suggesting that older adults had greater target word completion with subordinate homophones than dominant homophones.

Further analyses of the semantic and phonological conditions indicated an Age x Dominance interaction for the semantic condition, $F1$ (1, 108) = 15.94, MSE = .03, p < .017, $F2$

(1, 94) = 7.18, MSE = .02, $p < .009$, such that older adults had greater target completion for subordinate homophones than young adults ($p1 < .001$, $p2 < .001$). Further, older adults had greater target completion than young adults for dominant homophones in the item analysis ($p2 < .014$), with a similar but insignificant trend in the participant analysis ($p1 > .149$). In contrast, there was no Age x Dominance interaction for the phonological condition ($F1 < 1$, $F2$ (1, 94) = 2.12, MSE = .01, $p > .142$), suggesting that young and older adults had similar target completion for dominant and subordinate homophones in the phonological condition.

Further analyses of the dominance variable revealed an Age x Prime-Target Relationship interaction for subordinate homophones $F1$ (1, 108) = 17.76, MSE = .04, $p < .001$, $F2$ (1, 94) = 46.24, MSE = .01, $p < .001$. Older adults showed greater completion with the target in the semantic condition for subordinate homophones than young adults ($p1 < .001$, $p2 < .001$). Target completion in the phonological condition for subordinate homophones showed no age difference in the participant analysis ($p1 > .272$), although young adults had greater target completion than older adults in the item analysis, ($p2 < .023$). However, this target completion in the phonological condition favoring young adults for subordinate homophones appeared to be driven by one item (*guerilla-a____*) which had much greater completion with *ape* for young adults (75%) than older adults (33%); when this item was eliminated, the target completion advantage in the phonological condition favoring young adults for subordinate homophones disappeared, $p1 > .874$, $p2 > .06$. The Age x Prime-Target Relationship interaction for dominant homophones was only significant in the item analysis, $F1$ (1, 108) = 2.34, MSE = .03, $p > .129$, $F2$ (1, 94) = 5.39, MSE = .01, $p < .022$, such that older adults had greater target completion in the semantic condition than young adults for dominant homophones ($p2 < .038$), but equivalent target completion in the phonological condition ($p2 > .843$).

Analyses were performed that collapsed across dominance in order to see if there were any overall age differences in the semantic and phonological conditions. Age differences were

found for the semantic condition ($p1 > .002$, $p2 < .001$), such that older adults had greater target completion than young adults. In contrast, there were no age differences in the phonological condition ($p1 > .291$, $p2 > .082$).

Analyses Using a Difference Measure. The same analyses that are reported above were performed on the means after subtracting the baseline (unrelated) condition from each of the other four conditions (see Figure 5-1). This method provides a measure of priming, or the percent of time the target word was given in the experimental conditions minus the percent of time the target word was given in the unrelated condition (i.e., given by "chance"). A 2 (age) x 2 (prime-target relationship) x 2 (dominance) ANOVA on percent priming revealed identical patterns of results. Following up the three-way interaction revealed the same pattern as the above analyses using target word completion as the dependent measure.

Response Time. Invalid response times (RTs) were calculated for experimental trials only (excluding practice trials, fillers, foils, and any trials where participants gave a response that was categorized as an error, e.g., responded with a nonword or a word that began with the incorrect letter). RTs were considered "invalid" either when participants failed to trigger the microphone or the microphone triggered too early. Overall, invalid responses occurred on 11% of the trials (SD = 31%). RTs for young adults and older adults were invalid on 8% (SD = 28%) and 13% (SD = 34%) of the trials, respectively. Across the three conditions, young adults had invalid RTs for 9% of phonological, 8% of semantic, and 9% of unrelated trials. Older adults had invalid RTs for 14% of phonological, 14% of semantic, and 12% of unrelated trials. A 2 (age) x 2 (prime-target relationship) x 2 (dominance) ANOVA on the proportion of invalid RTs revealed only a significant main effect of Age, $F(1, 108) = 4.22$, $MSE = .06$, $p < .042$, suggesting that young adults had less invalid RTs than older adults.

Histograms of experimental trial RTs (excluding invalid RTs, practice trials, fillers, foils, and errors, leaving 2259 RTs for young adults and 1978 RTs for older adults) revealed slightly skewed distributions for young and older adults. Skewness (a measure of the asymmetry of a

distribution) was .955 (SE = .052) for the young adults' distribution and .814 (SE = .055) for the older adults' distribution. Kurtosis (a measure of the extent to which observations cluster around a central point) was .876 for the young adults and .278 for the older adults. Thus, log transformations of the raw RTs were conducted. Skewness for the post-transformation distribution was -.433 (SE = .052) for the young adults and -.459 (SE = .055) for the older adults. Kurtosis for the post-transformation distribution was 1.04 for the young adults and 2.30 for the older adults. Histograms indicated better-fitting distributions for both young and older adults after the log transformations.

RTs that were 2.5 standard deviations from each age group's mean were excluded from analyses. For experimental trials, young and older adults' mean RTs were 1613.12 ms (SD = 684.05 ms) and 1820.02 ms (SD = 694.20 ms), respectively. Thus, any RT over 3323.25 ms for young adults and 3555.52 ms for older adults was excluded from analysis, eliminating 61 RTs (2.7%) for young adults and 37 RTs (1.9%) for older adults.

Analyses on responses times (RT) where participants gave the target word were conducted to assess any change in RT when priming occurred. Tables 5-3 and 5-4 display mean raw and log RTs for the semantic, phonological, and unrelated conditions. Unfortunately, because the effect of phonological priming is so small (i.e., the target word was given relatively infrequently in the phonological condition), only 10 out of 55 young and 6 out of 55 older adults were able to be included in a RT subject analysis in the phonological condition. Similarly, only 5 dominant and 10 subordinate items (out of 96 total items) could be included in item analyses. In the unrelated condition, only 12 participants in each age group were included and only 3 items. In contrast, the semantic condition provided ample data for RT subject analyses: 44 young adults and 48 older adults for participant analyses, and 40 dominant and 39 subordinate stimuli for item analyses.

Analyses with raw RTs were complemented by analyses with log RTs. A 2 (age) x 2 (dominance) ANOVA on raw RTs in the semantic condition revealed a significant main effect of

Age in both participant (F1) and item (F2) analyses, $F1\ (1, 90) = 11.18$, $MSE = 156505.74$, $p < .001$, $F2\ (1, 77) = 27.18$, $MSE = 81358.08$, $p < .001$. A significant main effect of Dominance was found in the participant analysis, $F1\ (1, 90) = 7.69$, $MSE = 37951.53$, $p < .007$, but the effect was not significant in the item analysis, $F2\ (1, 77) = 2.35$, $MSE = 107586,83$, $p > .13$. There was no significant interaction, $F1\ (1, 90) = 1.88$, $MSE = 37951.53$, $p > .174$, $F2\ (1, 77) = 2.62$, $MSE = 81358.08$, $p > .11$. Analyses with log RT as the dependent measure were similar for the participant analyses, but slightly different for the item analyses. Both analyses revealed main effects of Age, $F1\ (1, 90) = 9.99$, $MSE = .02$, $p < .002$, $F2\ (1, 77) = 29.74$, $MSE = .01$, $p < .001$, and of Dominance, $F1\ (1, 90) = 10.13$, $MSE = .001$, $p < .002$, $F2\ (1, 77) = 3.53$, $MSE = .01$, $p < .064$, although the Dominance effect was marginal in the item analysis. The Age x Dominance interaction was marginally significant in the item analysis, $F2\ (1, 77) = 3.42$, $MSE = .01$, $p < .068$, but not in the participant analysis, $F1\ (1, 90) = 2.08$, $MSE = .001$, $p > .152$. The interaction in the item analysis revealed that young adults had faster semantic priming with dominant homophones than subordinate homophones ($p2 < .021$); older adults had equivalent RTs for dominant and subordinate homophones in the semantic condition ($p2 > .882$). A similar trend appeared in the raw RT analyses, although the overall interaction was not significant ($p2 > .11$, see above). Interestingly, this result mimics the target completion results where young adults showed more semantic priming for dominant homophones than subordinate ones, but older adults showed no difference in priming for dominant and subordinate homophones in the semantic condition.

In order to determine if RTs were faster when participants gave the target response (e.g., *sand* for *beech*) rather than an alternative response (e.g., *stick*), analyses were conducted comparing responses that matched the target and responses that did not match the target. Collapsing across Dominance, ANOVAs with Age and Matching Target Response were conducted for each Condition (semantic, phonological, unrelated) in order to retain the largest

sample of participants as possible (i.e., avoid data loss between conditions and dominance categories).

The 2 (age) x 2 (matching target response) ANOVAs on raw and log RTs in the semantic condition retained 50 young and 54 older adults and all 48 items. A main effect of Age for raw RTs ($F1$ (1, 102) = 11.56, MSE = 266727.87, $p < .001$, $F2$ (1, 47) = 37.74, MSE = 50081.88, $p < .001$) and for log RTs ($F1$ (1, 102) = 11.37, MSE = .03, $p < .001$; $F2$ (1, 47) = 47.91, MSE = .001, $p < .001$) indicated that young adults (M = 1461.83 ms) were faster to respond in the semantic condition than older adults (M = 1705.06 ms). A main effect of Matching Target Response for raw RTs ($F1$ (1, 102) = 93.68, MSE = 70691.92, $p < .001$, $F2$ (1, 47) = 43.29, MSE = 54962.51, $p > .288$) and for log RTs ($F1$ (1, 102) = 110.50, MSE = .001, $p < .001$; $F2$ (1, 47) = 32.22, MSE = .001, $p < .001$) indicated that participants responded faster in the semantic condition when their responses matched the target (M = 1409.33 ms) than when their responses did not match the target (M = 1767.37 ms). An Age x Matching Target Response interaction was not found in the participant analysis for raw or log RTs ($F1s < 1$); however, the item analysis revealed a significant interaction for log RTs ($F2$ (1, 47) = 6.11, MSE = .001, $p < .017$) but not for raw RTs ($F2$ (1, 47) = 6.11, MSE = 42871.17, $p > .122$). The interaction for log RTs in the item analysis revealed that young and older adults were faster to respond when their responses matched the target than when their responses did not match the target ($ps < .001$), but the effect was slightly larger for young adults than for older adults. However, this interaction must be interpreted with caution for two reasons. First, the means are quite different from the participant analysis that had an insignificant trend suggesting that older adults benefited more than young adults when their responses matched the target. Second, the item analysis was not significant for the raw RTs and inspection of individual items indicated that a small number of items were biasing the effect for young adults.

The 2 (age) x 2 (matching target response) ANOVAs on raw and log RTs in the phonological condition retained 39 young and 30 older adults and 22 items. A main effect of Age

was found for raw RTs ($\underline{F}1\ (1, 67) = 4.67$, $\underline{MSE} = 363944.54$, $\underline{p} < .034$, $\underline{F}2\ (1, 21) = 13.11$, $\underline{MSE} = 140485.36$, $\underline{p} < .002$) and for log RTs in the item analysis ($\underline{F}2\ (1, 21) = 13.12$, $\underline{MSE} = .01$, $\underline{p} < .002$), with the participant analysis being marginally significant ($\underline{F}1\ (1, 67) = 3.12$, $\underline{MSE} = .03$, $\underline{p} < .082$). Young adults ($\underline{M} = 1573.35$ ms) were faster to respond in the phonological condition than older adults ($\underline{M} = 1797.55$ ms). A main effect of Matching Target Response was found for raw and log RTs in the participant analyses ($\underline{F}1\ (1, 67) = 14.73$, $\underline{MSE} = 128943.01$, $\underline{p} < .001$ for raw RTs and $\underline{F}1\ (1, 67) = 12.00$, $\underline{MSE} = .01$, $\underline{p} < .001$ for log RTs), with a similar insignificant trends in the item analyses ($\underline{F}2\ (1, 21) = 1.19$, $\underline{MSE} = 188114.08$, $\underline{p} > .288$ for raw RTs and $\underline{F}2 < 1$ for log RTs). The main effect of Matching Target Response in the participant analyses indicated that participants responded faster when their responses matched the target ($\underline{M} = 1549.20$ ms) than when their responses did not match the target ($\underline{M} = 1792.80$ ms). There was no Age x Matching Target Response interaction for raw RTs ($\underline{p}1 < .393$, $\underline{p}2 > .640$) or log RTs ($\underline{p}1 > .605$, $\underline{p}2 > .442$), suggesting that young and older adults benefited equally from phonological priming when RT was the dependent measure, similar to results from target completion as the dependent measure.

The 2 (age) x 2 (matching target response) ANOVAs on raw and log RTs in the <u>unrelated condition</u> only retained 14 young and 14 older adults and 5 items. Although caution should be taken when interpreting these results because of the large data loss, no main effects or interactions were revealed ($\underline{p}s > .241$). Importantly, faster responses for responses that matched the target would not be expected in the unrelated condition because participants' responses presumably are not related in any way to the unrelated "prime" word (by being a semantic associate or a semantic associate of the homophone).

<u>Post-Experiment Questionnaire.</u> Table 5-5 displays the percent of young and older adults who responded with specific answers to the questions asked of them in the post-experiment questionnaire. Clearly, no participants were able to figure out the purpose of the experiment, although many assumed it had something to do with word association. Specifically, 62.3% of

young adults and 38.2% of older adults assumed the purpose had something to do with word associations. Further, 9.4% of young adults and 40% of older adults thought the purpose was to see how quickly they could respond (these percentages overlap slightly because 7.3% of older adults responded that they thought the experiment was about associations and response time). The remaining participants had individual ideas about the purpose of the experiment that are too numerous to list (and are far from correct).

Generally, people listed two types of strategies when asked if they had a strategy during the experiment. First, 81.1% of young adults and 80% of older adults reported having no strategy other than using the first word that came to mind. Second, 15.1% and 20% of young and older adults, respectively, reported trying to make an association between their response and the word given. However, the majority of these people reported not always being able to do this and would default to whatever came to mind for those trials. Finally, 3.8% (2 participants) of young adults reported some other strategy (e.g., rhyming).

Less than one-third of participants reported ever discarding their first response in exchange for an alternative response. Further, of those who reported discarding responses, they seem to have done so very infrequently (i.e., mostly less than five times in the entire experiment). The majority of participants reported not noticing anything unusual during the experiment, and the remaining participants incorrectly guessed at what was unusual (although some participants were aware that some responses were easier when they tended to "go together," e.g., *beach-sand*). Less than half of both age groups were familiar with homophones and even fewer (less than 20% of those who knew what homophones were), noticed homophones in the experiment. None of the participants who noticed homophones reported trying to respond any differently to those trials.

Discussion

Experiment 1 had two main findings. First, consistent with TDH's predictions but contrary to IDH's predictions, there were no age differences in the amount of phonological priming for either dominant and subordinate homophones. In addition, phonological priming was

greater for subordinate homophones than for dominant homophones for both young and older adults. Second, older adults had significantly more semantic priming than young adults for dominant and subordinate homophones. Further, overall, semantic priming was greater than phonological priming. Each of these findings is discussed in turn below.

Phonological Priming. The finding that young and older adults demonstrated similar amounts of phonological priming suggests that, similar to other forms of priming that show age-equivalence (e.g., repetition priming), phonological priming in word retrieval is less susceptible to age declines because it utilizes preexisting connections, ones that adults of any age have stored and used over a lifetime. Although older adults report more TOTs than young adults, a phenomenon that is caused by weakened connections to phonological nodes, increased TOTs most often occur for infrequently or nonrecently used words. In contrast, homophones are more commonly used words in everyday speech and writing and therefore older adults are less likely to have weakened connections to them than to infrequently or nonrecently used words.

For both age groups, the amount of phonological priming depended on the homophone's dominance. Consistent with NST, more phonological priming occurred for subordinate homophones due to the strength of the connections between the phonology and the lexical nodes. The homophones' phonology is more strongly connected to the dominant homophone's lexical node. When the subordinate homophone is activated, node priming travels to the phonological node(s), across the strong connection between the phonology and the dominant lexical node, and then over to the dominant homophone's associate. Finding more phonological priming for subordinate homophones is consistent with Lukatela and Turvey's (1994) finding of more phonological priming of semantic associates in word recognition when the lower-frequency homophone was the prime and the time course was longer (250 ms compared to 50 ms). Lukatela and Turvey argued that a word's phonology is initially activated, but that as the processing time increases, orthography influences word recognition and therefore less priming is seen at longer intervals between prime and target presentation (see also Van Orden, 1987). Because low-

frequency words take longer to activate, orthography does not exert its influence as quickly as it does for high-frequency words. This explanation is logical but a bit puzzling with the present results, as Lukatela and Turvey's results imply that phonological priming of semantic associates would not occur in word retrieval because of the longer time interval involved in word retrieval. Future research might investigate the time course of phonological priming in word retrieval to help put the pieces of this puzzle together.

The effect of dominance on phonological priming found in Experiment 1 is consistent with the findings of semantic priming of homographs and homonyms found by Gottlob et al. (1999). Gottlob et al. found that dominance effects were larger for homographs (which differ in phonology) than homonyms (which share phonology) because a word's phonology helps access the dominant meaning but hurts access to the subordinate meaning. Unlike homographs, homophones share phonology but differ in orthography. Further, unlike homonyms, homophones differ in orthography. According to Gottlob et al. (1999), in order for semantic processing to occur, orthographic (O) and phonological (P) dynamics must first stabilize, and this stabilization likely occurs faster for dominant homophones because they are activated more frequently than subordinate homophones. The present results are consistent with this prediction.

Experiment 1 demonstrated phonological priming of semantic associates in a <u>retrieval</u> paradigm. These results support similar findings from the word <u>recognition</u> literature (Lesch & Pollatsek, 1993; Lukatela & Turvey, 1994) and extend this phenomenon to longer-term (up to four seconds) <u>retrieval</u> paradigms. Unfortunately, there were too few response times to analyze the effect of dominance in the phonological condition and therefore no conclusions can be drawn with respect to response time for phonological priming of dominant and subordinate homophones. However, when collapsing across dominance and including responses that matched the target and responses that did not match the target, both age groups were faster to respond with a word that matched the target than they were to respond with a word that did not match the target. One interpretation of this finding is that the time to retrieve a word decreases when it is

primed with a homophone of a word that is semantically related to it. In other words, retrieval of words that are closely connected to one another, even phonologically, is faster than retrieval of words that are not closely connected to one another. Another interpretation of this finding is that the likelihood of observing phonological priming of semantic associates decreases as time elapses between presentation of the word-stem pair and a participant's response.

The phonological priming results were inconsistent with IDH (Hasher & Zacks, 1988), which predicted that older adults would show <u>more</u> phonological priming than young adults because of an inability to inhibit irrelevant associations. In contrast, young and older adults showed similar amounts of phonological priming, which is explained by TDH in terms of preexisting connections rather than inhibitory processes. It appears that, in this paradigm, either older adults did not have differentially more trouble inhibiting semantic alternatives to homophones than young adults or older adults did not activate the other alternatives in the first place.

<u>Semantic Priming.</u> Experiment 1 found that older adults demonstrated greater semantic priming than young adults, as evidenced by the percent of time the target response was given to a word stem paired with a semantically-related homophone. Further, older adults did not differ in the amount of semantic priming between dominant and subordinate homophones, whereas young adults had more semantic priming for dominant homophones than for subordinate ones. Although a decrease in semantic priming for subordinate homophones compared to dominant ones was not predicted for young adults, the finding can be explained by the frequency of word use. For young adults, less semantic priming occurs for subordinate homophones because of their lesser frequency of use, which leads to reduced activation of associated nodes. This effect does not occur for older adults who have more connections in their semantic networks that allow them to compensate for weaker connections to subordinate meanings (Laver & Burke, 1993). Thus, older adults do not exhibit the same decrease in semantic priming for subordinate homophones that young adults experience. Response time data were consistent with these findings of target

completion: Young adults were faster to respond to dominant homophones than subordinate homophones (in the semantic condition), whereas older adults did not differ in their response times to the two types of homophones. Interestingly, these age differences in the role of dominance in semantic priming occurred despite matching young and older adults on the homophones' semantic associates and dominance ratings through norming, suggesting that the age differences cannot be attributed to one group's bias towards or familiarity with homophone associates and homophone dominance.

Independent of dominance, older adults showed greater semantic priming overall than young adults (in percent completion with the target word), a finding that supports previous research on priming in word recognition tasks (Laver & Burke, 1993). Node Structure Theory maintains that older adults' more intricate semantic architecture allows them to offset any one weakened connection and to benefit more from semantic priming accumulating from many associations onto a target node. These results support this view and extend findings of greater semantic priming in word recognition for older adults than young adults to word retrieval. In contrast to older adults showing greater semantic priming than young adults with percent target completion, young and older adults did not differ in how quickly they produced a response in the semantic condition: both young and older adults were faster to respond when their response was the target word (i.e., a semantic associate) than when their response was not the target word. This finding complements the same finding for the phonological condition; namely, young and older adults are faster to respond when the response is strongly connected to the prime word than when the response is not strongly connected.

The finding that the amount of semantic priming was much greater than the amount of phonological priming for both ages is easily explained by the number of connections across which node priming must travel (see Figure 1-1). Semantic priming occurs between two nodes that share a single connection, and therefore node priming between two semantic associates is strong. In order for phonological priming to occur, node priming must theoretically spread across

three connections (from the homophone, down to its phonology, up to the other homophone, and over to its semantic associate). Assuming that node priming will weaken across every additional connection, phonological priming in this paradigm will always be less than semantic priming.

As a final methodological note, data from the post-experiment questionnaire indicated that no participants reported figuring out the purpose of the experiment, suggesting that the phonological priming manipulation was well disguised. Most importantly, although a few participants (19% of young and 16% of older adults) noticed that homophones were presented in the stimuli, none of these participants tried to use the homophones in any way differently than they tried to use the other stimuli. Thus, this task appears to be a good implicit priming paradigm.

Table 5-1

Background characteristics for young and older adults in Experiment 1

	Group					
	Young Adults			Older Adults		
Variable	N	Mean	SD	N	Mean	SD
Age*	55	18.72	1.41	55	73.09	7.01
Education (years)*	55	12.52	0.93	55	17.03	2.54
Vocabulary* (max = 25)	55	14.73	2.76	55	20.89	2.59
Forward digit*	55	7.84	1.17	54	7.35	1.12
Backward digit*	55	5.76	1.37	54	4.94	1.23
Health (max = 10)	55	8.17	1.23	54	7.98	1.45
MMSE (max = 30)				55	27.91	1.98

Note. Asterisks indicate significant differences between the age groups, $p < .05$. Participants who were missing data from particular characteristics were excluded from that analysis. Data from one older participant on the digit span tests is missing because he refused to participate in the test.

Table 5-2

Percent of time stem was completed with the target word (participant analysis)

	Prime-target relationship				
	Semantic		Phonological		
Age rroup	Dominant	Subordinate	Dominant	Subordinate	Unrelated
Young					
M	40.0	31.4	5.7	13.2	2.3
(SD)	(25.5)	(23.5)	(8.9)	(15.0)	(3.8)
Older					
M	47.1	50.3	5.1	10.0	2.4
(SD)	(26.0)	(25.7)	(8.0)	(16.0)	(4.2)

Table 5-3

Mean raw response times (in ms) for the two age groups, Experiment 1 (participant analysis)

	Prime-target relationship				
	Semantic		Phonological		
Age group	Dominant	Subordinate	Dominant	Subordinate	Unrelated
Young					
N	44	44	10	10	12
M	1204.50	1323.60	1550.30	1621.00	1470.58
(SD)	(305.68)	(353.66)	(518.39)	(463.74)	(457.19)
Older					
N	48	48	6	6	12
M	1439.08	1479.44	1314.33	1568.61	1707.50
(SD)	(287.76)	(299.41)	(333.09)	(421.70)	(510.60)

Table 5-4

Mean log response times for the two age groups, Experiment 1 (participant analysis)

	Prime-target relationship				
	Semantic		Phonological		
Age group	Dominant	Subordinate	Dominant	Subordinate	Unrelated
Young					
N	44	44	10	10	12
M	3.06	3.10	3.17	3.19	3.13
(SD)	(.14)	(.14)	(.15)	(.11)	(.21)
Older					
N	48	48	6	6	12
M	3.14	3.16	3.11	3.18	3.21
(SD)	(.09)	(.09)	(.12)	(.15)	(.13)

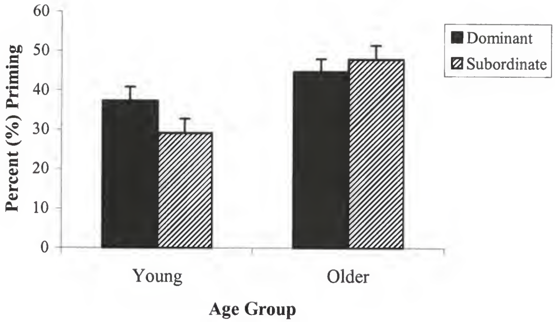
Table 5-5

Results of Experiment 1 post-experiment questionnaire.

Question	Age group: Young adults[a]	Age group: Older adults
(1) Figured out purpose	0%	0%
(3) Reported discarding a first response	28.3%	27.3%
(3a) Of those who discarded first response,% who discarded response on average:		
One time	14.3%	33.3%
Two to three times	64.3%	46.7%
Four to five times	21.4%	13.3%
Six to ten times	0%	6.7%
(4) Reported not noticing anything unusual during the experiment	60.4%	69.1%
(4) Reported noticing something unusual but were incorrect in their assessment	39.6%	30.9%
(5) Familiar with homophone	49.1%	47.3%
Of those who reported familiarity with homophones, % who:		
Noticed homophones in the experiment	19%	16%
Tried to use the homophones	0%	0%

[a] Questionnaires are missing for two young adults.
Note. The number next to each statement corresponds to the question number on the questionnaire (see Appendix F).

A



B

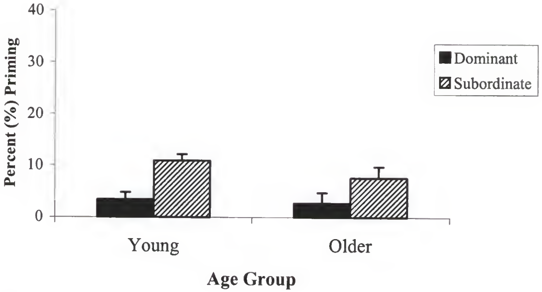


Figure 5-1. Semantic and phonological priming in Experiment 1. A) Semantic priming. B) Phonological priming. The amount of semantic and phonological priming for young and older adults and dominant and subordinate homophones in Experiment 1. The dependent measure, "percent priming," is the percent of time participants completed the word stem with the target word in the semantic or phonological conditions minus the percent of time they completed the word-stem with the target word in the unrelated condition.

CHAPTER 6
EXPERIMENT 2: PHONOLOGICAL PRIMING OF NEW ASSOCIATIONS

Experiment 2 expanded on the findings of Experiment 1 by investigating the effects of aging on priming new associations in a word-stem completion paradigm. Some research has suggested that older adults have more difficulty than young adults when asked to explicitly form and implicitly retrieve new associations (Howard, Heisey, & Shaw, 1986; Howard, Fry, & Brune, 1991). Other research shows that young and older adults perform similarly under implicit learning situations (e.g., reading unrelated word pairs) that require the formation of new associations (Light et al., 1995, 1996; see Spieler & Balota, 1996 for an exception). These implicit studies suggest that new learning may be equivalent for young and older adults when the learning and testing conditions are implicit (rather than explicit) and require reading or recognition. However, older adults' ability to form new connections under implicit retrieval conditions (Light and colleagues' studies required reading, a word recognition task) is unknown. The study of implicit retrieval versus recognition can be compared to the study of these tasks under explicit conditions: Older adults show greater deficits on explicit tasks that require recall than on explicit tasks that require recognition, presumably because recognition tests provide (at least partial) information for the adult (see Craik & Jennings for a review, 1992). In contrast to explicit tests, implicit tests eliminate the conscious recollection component that usually hinders recall compared to recognition, allowing the possibility that older adults may not have difficulties retrieving under implicit conditions.

In addition to exploring how older adults fared on tasks that require the implicit formation and retrieval of new associations, this experiment investigated the role that phonology plays in learning new associations. As mentioned previously, NST predicts that priming across

connections is weaker for new associations because they have not had the advantage of being activated as often as preexisting associations, especially for older adults. That is, when associating two unrelated words (as is often required in experiments that investigate new learning), a new connection must be formed between the two previously unrelated words (i.e., two previously uncommitted nodes, e.g., *beach* and *laugh*). Because the connection is new, it is by its nature weaker than a connection between two words that has been repeatedly strengthened across a long time period (e.g., *beach* and *sand*). Further, NST maintains that, in general, older adults have weaker connections than young adults; therefore, new connections are going to be differentially weaker for older adults than for young adults.

In the present experiment, participants formed a relationship (i.e., new association) between two words without conscious awareness of doing so (i.e., implicitly). Participants completed a list of association stem completions with the first word that came to mind. Phonological priming was assessed by having participants respond to the same stem (e.g., *l*____) paired with both members of a homophone pair (e.g., *beach*, *beech*). Semantic priming was assessed by having participants respond to the same stem (e.g., *l*____) paired with a homophone (e.g., *beach*) and later paired with the homophone's semantic associate (e.g., *sand*). It was assumed that whatever response participants gave to the word stem would be associated with the (prime) word that it was paired with. The use of word-stem completion in this new paradigm was different from previous experimental uses of word-stem completion in that there was no "study phase" included in this paradigm, reducing the probability that participants would use explicit (i.e., conscious) retrieval strategies when completing the stems. Previous studies that used word-stem completion to test implicit memory did so after "priming" participants with specific information during a test phase (e.g., studying word pairs, taking a vocabulary quiz; "priming" is placed in quotation marks to emphasize that exposing participants to information during a study phase introduces explicit contamination and therefore may not be truly implicit).

Similar to Experiment 1, this paradigm permitted a test of phonological priming across meanings of a homophone. However, this experiment differed in two ways from Experiment 1. First, both words of a homophone pair (e.g., *beach*, *beech*) were presented in the list, although not consecutively. Second, there was no prior relationship between the homophone prime and its stem; rather, whatever word the participants produced to fit the stem served as their association. For example, participants might have seen the prime-target stem *beech-l*_____ and produced the response *laugh.* Later in the test list, participants encountered the other homophone paired with the same stem (e.g., *beach-l*_____). Thus, this experiment also differed from previously used implicit tasks by not presenting participants with the same (prime) word on two occasions; rather, participants were presented with the homophone of an earlier-presented word. This further reduced the likelihood that participants could "think back" to an earlier presented word and form a relationship. The issue of "thinking back" to an earlier presentation (or study phase) is critical in Experiment 2 because both members of a homophone were presented. This issue was not relevant to Experiment 1 because participants only encountered a homophone on one occasion.

Phonological priming across new associations was demonstrated to the extent that participants completed the second homophone target-stem with the same word they used to complete the first homophone target-stem (*laugh*). Phonological priming in this paradigm indicates that a new association was formed between *beech* and *laugh*; this new association then facilitated retrieval of *laugh* when later paired with the homophone *beach* (see Figure 6-1). If phonological priming was observed in this task, I could conclude that phonological priming between a word and unrelated semantic meanings can be observed even for new associations.

A different form of semantic priming was used by presenting a homophone early in the task, and later presenting a semantic associate of that homophone (e.g., presenting *beach-l*____ followed by *sand-l*_____). Thus, a comparison between semantically related words served as the form of semantic priming. This form of semantic priming differed from traditional forms of

semantic priming where an immediate response is given after presentation of two synonyms (e.g., *doctor-nurse*).

Experiment 2 compared participants' responses in three prime conditions that were similar to Experiment 1: (1) *beach-l*____ and *sand-l*_____ (a measure of semantic priming), (2) *beach-l*_____ and *beech-l*_____ (a measure of phonological priming), and (3) *beach-l*_____ and *batch-l*______ (a baseline (unrelated, orthographic control) measure). As in Experiment 1, dominant and subordinate homophones were included. Similar to Experiment 1, two implicit measures were recorded: percent of time participants completed the second stem with the same target word as the first stem, and response time to complete the stems. Requiring a speeded word-stem completion test was intended to minimize the probability that participants would try to think back to prior target-stems and form a relationship between homophones, even though there was no explicit relationship.

Predictions

For both percent word-stem completion and response time, main effects of Age, Dominance Order, and Prime Condition were predicted, but were expected to be mediated by an Age x Dominance Order x Prime Condition interaction (note that "Prime Condition" describes the relationship between the first encounter of a homophone and the second encounter of that homophone's homophone, semantic associate, or orthographic control word). As described in Experiment 1, dominance order was expected to influence the activation of the phonological representations: More phonological priming was expected when the subordinate homophone (*beech*) was presented first, followed by dominant homophone (*beach*) than when the dominant homophone was presented first and followed by the subordinate homophone (see Experiment 1 predictions for a similar dominance argument).

For phonological and semantic conditions, young adults were expected to exhibit more priming (i.e., complete more word stems with same target word for both instances of the

homophones) than older adults. Node Structure Theory and TDH predict more priming for young adults because older adults have difficulty forming new associations and show reduced priming of these associations. However, new learning under implicit retrieval conditions has not been tested within the NST framework; therefore, it is possible that implicit conditions will allow older adults the support (context) they need to demonstrate new learning, as in the experiments by Light et al. (1995, 1996) with word recognition. Further, under the IDH framework, older adults would be expected to show more priming than young adults of new associations because of sustained activation from their first completion to their second completion. Although researchers such as Graf and Schacter (1985, 1986) and Micco and Masson (1991) do not speculate about age differences in new association priming, their results are at least relevant to young adults who participated in Experiment 2. Whereas Graf and Schacter would argue that priming between new associations should not occur in Experiment 2 because participants do not elaborate on the associations, Micco and Masson's predictions would likely support NST's: Young adults should show priming of new associations because any encounter with the association produces unitization of the previously unrelated words.

For young adults, NST predicted that more word stems would be completed with the target word in the phonological condition than the semantic condition, contrary to Experiment 1. Priming was expected in the phonological condition because an identical phonological representation (/bēch/) is activated upon presentation of either *beach* or *beech*. Suppose a direct connection has been formed between *beach* and *laugh* on the first presentation (see Figure 6-1). When *beech-l*____ is encountered on the second presentation, node priming is likely to travel from the phonology (/bēch/) to the other instance of the homophone, *beach*, and achieve activation. Once activated, if the newly formed connection between *beach* and *laugh* is strong enough, then *laugh* will get activated and result in retrieval of the same word twice. Less priming was predicted in the semantic condition than in the phonological condition. When first encountering the homophone (e.g., *beach*), a direct connection should be formed between that

word and the word used to complete the stem (e.g., *laugh*). When encountering the second word in the semantic condition (e.g., *sand*), some node priming should spread to *beach* because it is a semantic associate of *sand* (especially for more strongly associated words; however, not all of the semantic associates were strongly associated due to constraints discussed in the pilot studies). Less node priming was expected to activate *beach* because when *sand* is activated, a set amount of node priming must spread across all of its semantic associates (e.g., *ocean, castle*), of which *beach* is only one.

Method

Participants. Sixty young (ages 18-24; $M = 19.21$, $SD = 1.33$) and 60 older (ages 61-86; $M = 72.68$, $SD = 6.55$) adult participants were recruited in the same manner as discussed in Experiment 1. The same background information was collected for this experiment as indicated in Experiment 1 (see Table 6-1). Scores are based on 57 young adults and 50 older adults because these were the participants included in analyses (the remaining participants were excluded for not following directions or for having difficulties with the task). Young adults included 39 females and 18 males, and older adults included 25 females and 25 males. Independent samples t-tests indicated that young adults had less years of education, $t(105) = -9.85$, $p < .001$, and worse vocabularies, $t(105) = -9.27$, $p < .001$ than older adults, but larger forward, $t(105) = 2.56$, $p < .012$ digit spans. Although young adults tended to have larger backward digit spans, the difference was only marginally significant, $t(105) = 1.62$, $p < .11$. Young and older adults did not differ on self-reported health, $p > .45$.

Design. The experimental design was similar to Experiment 1, with Age (young, older adults) as a between-participants factor, and Prime Condition (semantic, phonological, unrelated) and Dominance Order (dominant homophone presented first, subordinate homophone presented first) as within-participants factors. The one difference in design between Experiments 1 and 2 was that Experiment 1 had dominance inherent in the homophone (either dominant or subordinate), and Experiment 2 manipulated the order in which the homophones were presented

(either dominant or subordinate presented first in the list). The dependent variables were the percent of time word stems were completed with the same target word, and the time to responds to each stem.

Apparatus. The experiment was performed on Pentium II 350 MHz IBM-compatible computers using a program written in Visual Basic. The microphone used to record response times was the Cyber Acoustics Desktop Standing Microphone.

Materials. Young and elderly adults were presented with the word-stem completion test, which consisted of the same 48 homophone pairs (96 total homophones) that were included in Experiment 1 (excluding foils). These homophones were paired with a different word stem than they were paired with in Experiment 1: Each homophone was paired with a letter that did not elicit any obvious semantic responses (e.g., *l*___ for *beach*), and members of a homophone pair were paired with the same word stem (e.g., *beach-l*____, *beech-l*____). In addition, 49 non-homophone filler stems intended to disguise the presence of homophones were included. Five non-homophone practice trials began the experiment.

Similar to Experiment 1, Experiment 2 had three conditions (semantic, phonological, and unrelated) and 2 dominance categorizations (dominant, subordinate). However, unlike Experiment 1, the present experiment required that one of the words in the homophone pair (e.g., *beach-l*_____) be presented prior to either a semantic associate (semantic condition; e.g., *sand-l*____), the other word in the homophone pair (phonological condition; e.g., *beech-l*_____), or a word that was orthographically related to one of the homophones in a pair (unrelated condition, e.g., *batch-l*____). Thus, dominance referred to which member of the homophone was presented first in the list, the dominant or subordinate one (hereafter referred to as "dominance order" for clarity). Members of each experimental word-stem pair (semantic, phonological, or unrelated) were separated by eight other word stems, such that members of an experimental pair fell in positions 1 and 10, 2 and 11, and so on in the word stem list. Further, a non-homophone filler

word stem was presented after every two experimental word stems. An example order including the homophones *beach* and *beech* was: inn-f____, *beach-l____*, sleep-r____, day-y____, park-w____, beard-e_____, aunt-g____, choral-h_____, brush-j____, it-f____, *beech-l____*.

Pilot testing of experimental word stems prior to the actual experiment eliminated potential stems that could obviously be completed with a word that was semantically related to the homophone. For example, the word-stem pair *urn-b___* was changed to *urn-k____* because *burn* was a potential semantic (and rhyming) response to the word stem *b____*.

Twenty-four of the 26 letters of the alphabet were used as word-stems (*x* and *z* were excluded because very few common words begin with those letters). The 24 stems were each paired with an experimental pair twice (for a total of 4 presentations of each letter) and with a filler word stem twice. Thus, each of the 24 letters was presented six times in the experiment (with the exception of five letters (r, f, l, w, g) that were also used in the practice trials). The 24 letters were randomized and then the experimental pairs and fillers were assigned to the letters in the following order: b, n, a, m, t, s, k, g, d, c, l, p, v, o, r, e, j, u, y, w, g. The entire list of 24 randomized letters was completed before the letter cycle was repeated. Thus, no word-stem pairs that shared the same word stem as the experimental pair were presented in between an experimental pair (e.g., the word-stem *l____* was not presented in between the experimental stems *beech-l____* and *beach-l____*). These precautions were taken in order to minimize the likelihood of responses being repeated again and again (i.e., repetition priming). Once a word stem (e.g., *l____*) had been presented with an experimental homophone pair, it was then paired with a filler word (e.g., *actor-l____*) and was not again paired with another experimental pair until at least 43 word stems later. For example, out of 145 stimuli positions in each list, the word stem *l____* was paired with a filler (*cloud-l____*) in position 18, with experimental pairs in positions 62 and 71, with a different filler (*actor-l____*) in position 90, and with another experimental pair in positions 134 and 143.

The semantic condition used many of the semantic associates that were used as targets in Experiment 1. However, readers should recall that some of Experiment 1's homophones could not be paired with the strongest semantic associate due to stimuli issues (e.g., *smell* was not be paired with *scent* because both words start with "s" and I wanted to avoid eliciting homophones, e.g., *sent*, as responses). Experiment 2 did not have this problem because the semantic associate was presented after its homophone (e.g., *scent-h*____ preceded *smell-h*____) and not along-side its homophone as the word stem (e.g., *scent-o*___ in Experiment 1). Thus, in order to increase the strength of association between a homophone and its semantic associate (and therefore increase the chance of semantic priming, 34 of the 96 semantic associates (35%) were changed between Experiments 1 and 2. Table C-3 lists Experiment 2's homophones and semantic associates, and asterisks (*) indicate a change in semantic associate from Experiment 1 to Experiment 2.

Both the dominant and subordinate members of a homophone pair were counterbalanced across participants so that one word from the pair occurred first for half of the participants and the other word of the pair occurred first for the other half of the participants.

Similar to Experiment 1, participants in Experiment 2 received a verbal questionnaire after completion of the experiment (see Appendix G). A few changes were made from the questionnaire used in Experiment 1 to that used in Experiment 2. First, an additional question was added that asked participants if they actively tried not to use the same response twice (question 3b). Second, participants were asked to define a homophone instead of reporting whether they were familiar with homophones (question 5). Third, if they noticed homophones in the experiment (question 5a), they were asked if they were asked if they tried to use the homophones in any way and if so, *how* (question 5c). Finally, participants were asked if they responded to the homophone word stems any <u>differently</u> than they responded to any of the other word stems (question 5d).

<u>Procedure.</u> The procedure for Experiment 2 was identical to that of Experiment 1 with the exception that Experiment 2 contained 150 total word stems instead of 90.

Results

Three young adults and 10 older adults were excluded from analyses for not following directions (e.g., did not read the prime word), having perceptual difficulties with the task, or reporting they (repeatedly) intentionally inhibited responses or tried not to use the same word twice. Means and standard deviations for each prime condition, dominance order, and age can be found in Table 6-2. In contrast to Experiment 1, Experiment 2's unrelated condition could be included in the ANOVA because it was crossed with dominance (i.e., an unrelated, orthographic control word-stem pair followed either a dominant homophone or a subordinate homophone). A 2 (age) x 3 (prime condition) x 2 (dominance order) ANOVA on the percent of time the same target word was given for an experimental pair only revealed a main effect of Prime Condition, $F1\ (2, 210) = 9.38$, $MSE = 03$, $p < .001$, $F2\ (2, 186) = 9.04$, $MSE = 03$, $p < .001$ (see Figure 6-2). All other main effects and interactions were not significant, $Fs < 1$ (except the Age main effect in the item analysis, which was marginally significant favoring young adults, $F2\ (1, 93) = 3.61$, $MSE = 03$, $p < .061$). The percent of time the same target word was given for a homophone and its semantic associate (semantic condition) was greater than the percent of time the same target word was given for a homophone and its unrelated, orthographic control word (unrelated condition), $p1 < .001$, $p2 < .001$, indicating semantic priming. Similarly, the percent of time the same target word was given for both members of a homophone pair (phonological condition) was greater than the percent of time the same target word was given in the unrelated condition, $p1 < .001$, $p2 < .001$, indicating phonological priming. There were no differences in the percent of time the same target word was given in the semantic and phonological conditions, $p1 > .933$, $p2 < .929$, suggesting that the size of the priming effect was equal.

Analyses Eliminating Repeated Previous Responses. Experiment 2 differed from Experiment 1 in that the word stems in Experiment 2 did not have a completion that was obviously semantic (whereas in Experiment 1 many of the word stems fell into the semantic condition, e.g., beach-s____). Hence, because there were no overridingly strong semantic

completions in Experiment 2, people tended to repeat responses that began with the same letter (something that experimenters observed while running the experiment and participants asked about during the debriefing session). Because this repetition priming (i.e., once a response had been given, it was primed and often given again) was so noticeable, analyses were conducted to ensure that giving a response prior to an experimental pair did not alter the amount of semantic and phonological priming seen with the experimental pair.

A 2 (age) x 3 (prime condition) x 2 (dominance order) x 2 (previous response) ANOVA was performed on the percent of time the same target word was given for an experimental pair. Previous Response was defined as either never giving the target response prior to encountering the experimental pair, or giving the response at least once (the most was six times) prior to using the same word for the experimental pair. Unfortunately, this analysis eliminated 88 participants (46 young and 42 older adults), leaving only 19 cases to be analyzed (and 68 cases in the item analysis, leaving 28 to be analyzed). Nevertheless, there was a main effect of Previous Response, $\underline{F}1\ (1, 17) = 15.03$, $\underline{MSE} = .11$, $\underline{p} < .001$, $\underline{F}2\ (1, 26) = 34.72$, $\underline{MSE} = .09$, $\underline{p} < .001$, suggesting that the same word was given for an experimental pair more often when it had been given previously as a response than when it had not been given previously. Eliminating the dominance order variable, a 2 (age) x 3 (prime condition) x 2 (previous response) ANOVA only lost 37 participants (17 young and 20 older adults), leaving 70 cases to be analyzed (and 22 cases in the item analysis, leaving 26 to be analyzed). This ANOVA also revealed a main effect of previous response, $\underline{F}1\ (1, 68) = 12.88$, $\underline{MSE} = .08$, $\underline{p} < .001$, $\underline{F}2\ (1, 25) = 68.64$, $\underline{MSE} = .04$, $\underline{p} < .001$, suggesting that a response was more likely to be given for an experimental pair if it was previously given ($\underline{M}1 = 39.17$, $\underline{SD} = 18.60$; $\underline{M}2 = 43.23$, $\underline{SD} = 28.58$) than if it had not been given as a response previously ($\underline{M}1 = 29.20$, $\underline{SD} = 36.33$; $\underline{M}2 = 24.37$, $\underline{SD} = 16.28$) in the experiment. No other main effects or interactions were significant.

The main analysis, a 2 (age) x 3 (prime condition) x 2 (dominance order) ANOVA, was conducted after excluding all cases where a response was given prior to the first encounter of an

experimental pair (see Table 6-3). This analysis revealed the same effect as the analysis that included previous responses: a Prime Condition main effect, $\underline{F}1$ (2, 208) = 9.62, $\underline{MSE}$ = 04, $\underline{p}$ < .001, $\underline{F}2$ (2, 184) = 13.12, $\underline{MSE}$ = .03, $\underline{p}$ < .002, but no other main effects or interactions. The semantic condition ($\underline{M}$ = 27.8, $\underline{SD}$ = 22.7) had greater completion with the same word than the unrelated condition ($\underline{M}$ = 20.65, $\underline{SD}$ = 22.3), $\underline{p}1$ < .001, $\underline{p}2$ < .001. Similarly, the phonological condition ($\underline{M}$ = 28.2, $\underline{SD}$ = 26.1) had greater completion with the same target word than the unrelated condition ($\underline{p}1$ < .001, $\underline{p}2$ < .001), but the semantic and phonological conditions did not differ, $\underline{p}1$ > .933, $\underline{p}2$ > .929.

Response Time. Similar to Experiment 1, practice trials, fillers, and any trials where participants gave a response that was categorized as an error were excluded from analyses. Also similar to Experiment 1, response times (RTs) were considered "invalid" either when participants failed to trigger the microphone or the microphone triggered too early. Overall, invalid responses occurred on 16% of the trials ($\underline{SD}$ = 37%). RTs for young adults and older adults were invalid on 15% ($\underline{SD}$ = 36%) and 17% ($\underline{SD}$ = 38%) of the trials, respectively. Across the three conditions, young adults had invalid RTs for 15% of phonological, 16% of semantic, and 15% of unrelated trials. Older adults had invalid RTs for 19% of phonological, 17% of semantic, and 17% of unrelated trials. A 2 (age) x 3 (prime condition) x 2 (dominance order) ANOVA on the proportion of invalid RTs revealed no significant main effects or interactions, $\underline{p}$s > .05. Unlike Experiment 1, young and older adults did not differ on the amount of invalid RTs.

All response time (RT) analyses were calculated for the second encounter of experimental trials only (e.g., if participants saw *beech-l*____ and then *beach-l*____, response times were calculated for *beach-l*____ only). The question of interest was whether RT on the second encounter of the word stem was accelerated due to the previous encounter of the word stem, and whether this differed across the three conditions. Histograms of the RTs for the second instance of the experimental trails (excluding the first instance of an experimental trial, invalid RTs, practice trials, fillers, and errors, leaving 1875 RTs for young adults and 1551 RTs for older

adults) revealed slightly skewed distributions for young and older adults. Skewness was .877 (SE = .057) for the young adults' distribution and .780 (SE = .062) for the older adults' distribution. Kurtosis was .395 for the young adults and .028 for the older adults. Thus, log transformations of the raw RTs were conducted. Skewness for the post-transformation distribution was -.014 (SE = .057) for the young adults and -.093 (SE = .062) for the older adults. Kurtosis for the post-transformation distribution was -.301for the young adults and -.390 for the older adults. Histograms indicated better-fitting distributions for both young and older adults after the log transformations.

RTs that were 2.5 standard deviations from each age group's mean were excluded from analyses. For experimental trials, young and older adults' mean RTs were 1749.42 ms (SD = 691.40 ms) and 1771.40 ms (SD = 731.21 ms), respectively. Thus, any RT over 3477.92 ms for young adults and 3599.43 ms for older adults was excluded from analysis, eliminating 43 RTs (2.3%) for young adults and 29 RTs (1.7%) for older adults.

A 2 (age) x 3 (prime condition) x 2 (dominance order) x 2 (matching responses) ANOVA was performed on both raw and log RTs. "Matching Response" refers to whether participants gave the same response to an experimental pair (e.g., *laugh* to *beach-l____* and *beech-l____*). Matching Response was included as a variable in order to assess whether RTs were facilitated when priming occurred. Unfortunately, this ANOVA eliminated 80 participants (43 young and 37 older adults, leaving only 14 and 13 participants) and 67 items (34 dominant items and 35 subordinate items, leaving on 14 and 15 items); therefore, this analysis was misleading and will not be interpreted. Therefore, similar to Experiment 1, 2 (age) x 2 (dominance) x 2 (matching responses) ANOVAs were performed for each Prime Condition (semantic, phonological, unrelated). Means and standard deviations for each Prime Condition can be found in tables 6-5 (raw RT) and 6-5 (log RT).

A 2 (age) x 2 (dominance order) x 2 (matching) ANOVA on RTs in the semantic condition eliminated 47 participants (leaving 26 young adults and 34 older adults to be analyzed)

and 30 items (leaving 33 dominant and 33 subordinate items to be analyzed). The Matching Responses main effect was significant for log RTs ($F1$ (1, 58) = 4.84, MSE = .01, $p < .032$, $F2$ (1, 64) = 23.92, MSE = .02, $p < .001$) and for raw RTs in the item analysis ($F2$ (1, 64) = 18.42, MSE = 236580, $p < .001$), but not for raw RTs in the participant analysis ($F < 1$). This main effect suggested that participants were faster to give a response (e.g., *laugh*) to a semantic associate of a homophone (e.g., *sand*) when their response matched that given to the homophone (e.g., *beach*). Participant analyses on raw and log RTs revealed a significant Dominance Order x Matching Response interaction for raw RTs ($F1$ (1, 58) = 6.99, MSE = 628618.32, $p < .011$) and for log RTs ($F1$ (1, 58) = 9.01, MSE = .01, $p < .004$). In contrast, this interaction was not significant in the item analyses for raw RTs ($F2$ (1, 64) = 1.31, MSE = .236580.06, $p > .256$) or log RTs ($F2$ (1, 64) = 1.97, MSE = .02, $p > .165$). Further analysis of the Dominance Order x Matching interaction indicated a dominance effect for matching responses ($p1 < .039$ for raw RTs; $p1 < .017$ for log RTs), such that participants were faster to respond to a semantic associate when it was preceded by a dominant homophone than to an associate preceded by a subordinate homophone), but no dominance effect for nonmatching responses ($p1 > .158$ for raw RTs; $p1 > .135$ for log RTs). No other main effects or interactions were significant for raw and log RTs in the participant and item analyses ($p1s > .174$; $p2s > .06$).

A 2 (age) x 2 (dominance order) x 2 (matching responses) ANOVA on RTs in the phonological condition eliminated 50 participants, leaving RTs from 31 young adults and 26 older adults to be analyzed. Thirty-two items were eliminated from the item analysis, leaving 32 dominant and 32 subordinate items to be analyzed. The main effect of Matching Responses was significant for log RTs ($F1$ (1, 55) = 6.42, MSE = .01, $p < .014$, $F2$ (1, 62) = 77.33, MSE = .01, $p < .001$) and for raw RTs in the item analysis (F (1, 62) = 75.16, MSE = 181499.52, $p < .001$), but not for raw RTs in the participant analysis (F (1, 55) = 2.73, MSE = 135695.14, $p > .104$). The Matching Responses main effect indicated that participants were faster to respond to a homophone followed by its homophone when their responses matched on both occasions than

when their responses did not match. There were no other main effects or interactions for raw RTs ($p1 > .086$, $p2 > .06$) or log RTs ($p1 > .05$, $p2 > .05$).

A 2 (age) x 2 (dominance order) x 2 (matching responses) ANOVA on RTs in the unrelated condition eliminated 59 participants (leaving RTs from 28 young and 20 older adults to be analyzed) and 36 items (leaving RTs from 31 dominant and 29 subordinate homophones to be analyzed). A significant main effect of Matching Responses occurred for log RTs, $F1$ (1, 46) = 5.15, $MSE = .01$, $p < .028$, $F2$ (1, 58) = 37.54, $MSE = .02$, $p < .001$, and for raw RTs in the item analysis ($F1$ (1, 58) = 33.02, $MSE = 215182.48$, $p < .001$) but not in the participant analysis ($F1$ (1, 46) = 3.27, $MSE = 124872.13$, $p < .077$). Participants were faster to respond to an unrelated word preceded by a homophone if their response matched that given to the homophone than they were if their response did not match that given to the homophone, suggesting a repetition priming effect. No other main effects or interactions reached significant for raw RTs ($p1s > .121$) or log RTs ($p1s > .128$).

Post-Experiment Questionnaire. Table 6-6 shows the results of the post-experiment questionnaire. Two young adults and one older adult guessed as to the purpose of the experiment, although none of these participants were sure of his or her guess (and none of them tried to respond any differently to the homophones than they did to any other word-stem pairs). Similar to Experiment 1, many of the participants thought the purpose had something to do with word associations: 43.9% of young adults and 38.0% of older adults. Further, 7.0% of young adults and 16% of older adults thought the purpose was to see how quickly they could respond. The remaining participants had individual ideas about the purpose of the experiment that re too numerous to list.

In general, people listed two types of strategies when asked if they had a strategy during the experiment. First, 80.7% of young adults and 74% of older adults reported having no strategy other than using the first word that came to mind. Second, 14% of young adults and 24% of older adults reported trying to make associations between their response and the word given, although

the majority of these participants commented that they were unsuccessful. Finally, 1.8% (1 participant) and 2% (1 participant) of young and older adults, respectively, reported some other strategy (e.g., rhyming).

Although over one-third of participants reported discarding their first response in exchange for an alternative response, no participants reported doing so over 10 times (out of 150 word-stem pairs). The exact same number of participants who reported discarding their first response for an alternative response also tried actively not to use the same response twice (which is logical because these questions ask similar things). Although those participants who reported trying not to use the same response twice were not specifically asked how often they did this, some of them offered this information. Of those who did offer this information, 23.8% of young adults and 23.5% of older adults reported only doing this once, and 38.1% and 47.1% of young and older adults, respectively, reported only doing this two to three times. Further, 28.6% of young adults and 5.9% of older adults reported trying not to use the same responses four to five times, and 9.5% of young adults and 23.5% of older adults reported doing so between six and ten times. These participants were not excluded from analyses because they reported discarding their first response very infrequently, i.e., less than 10 times at the most.

Although the majority of participants reported noticing nothing unusual during the experiment or incorrectly guessed at what was unusual, 12.3% of young and 4% of older adults correctly reported that they thought the use of "similar words" (i.e., homophones) was unusual. However, of all the participants who could define "homophone" and noticed them in the experiment, none of them reported trying to use the homophones in any way or trying to respond any differently to the homophone trials.

Discussion

The main finding of Experiment 2 was that young and older adults were able to form new associations under implicit "study" and implicit retrieval conditions. Further, both age groups

showed equivalent amounts of phonological and semantic priming across new associations (compared to an orthographic control (unrelated) condition). Interestingly, these effects were not due to repetition priming (i.e., repeating one response multiple times when encountering a given one-letter stem) because the priming effects remained after excluding all cases where a response was given prior to the first encounter of an experimental pair.

The finding that older adults were equally able to form and retrieve new associations has important implications for studies of implicit memory. First, previous studies (Howard et al., 1986, 1991) that asked older adults to explicitly study new associations and then complete an association word-stem completion test (which was presumably implicit) found that older adults were at a disadvantage unless given ample study opportunity. The current findings suggest that study time is not critical if it is done implicitly, for participants were only given up to four seconds to make their response (and "learn" the association). In addition, Experiment 2's findings suggest that when the explicit component is removed from the learning situation, older adults are able to learn new associations as equally well as young adults. These findings complement those of Light and colleagues (1995, 1996) who found equivalent repetition priming of nonwords in young and older adults. The present experiment also extended these findings to a retrieval task (Light et al. (1995, 1996) used a recognition paradigm). Further, the present experiment extended these findings from nonwords to phonological and semantic associations between words.

Based on NST's predictions, forming new connections between two previously unrelated words was expected to be more difficult for older adults due to a general weakening of connections in old age. As discussed previously, new learning requires uncommitted nodes to undergo commitment learning, a process that involves repeated and prolonged activation of the uncommitted nodes. Because newly committed nodes are fragile, they must become activated within a brief time period after commitment or else the connection strength can decay.

Interestingly, older adults did not have differentially greater problems than young adults with forming new connections under implicit learning and testing conditions. Nevertheless, these results are unable to tell us how long this new connection will last; in this task, depending on who quickly a participant completed eight intervening word stems, the time interval between forming the association and again retrieving that association was merely 15 to 30 seconds; hence, it is unknown how long the new connection will remain sufficiently strong to enable reactivation. The short time interval could have been to the older adults' advantage, and the strength of the recently formed connection could differentially weaken over time for young and older adults. NST would predict that the new connection would weaken over time if commitment learning did not continue, i.e., if the newly-formed committed nodes were not repeatedly strengthened. The time course of new association priming and the amount of commitment learning required to form a strong connection are issues for future investigation.

The finding that young and older adults were able to form new associations after one presentation supports previous research that has demonstrated priming of new associations without elaborative processing at study (Goshen-Gottstein & Moscovitch, 1995; McKone & Tyrnes, 1999; Micco & Masson, 1991; Poldrack & Cohen, 1997). Thus, Experiment 2 provides further evidence that elaborative processing is not needed to form new associations, at least when learning and testing situations are both implicit. Possibly studies that found a need for elaborative processing (Graf & Schacter, 1985, 1986) did so because their participants learned the new information under explicit study conditions, or because their participants used explicit processes during the testing phase (i.e., explicit contamination). The former possibility suggests that when an implicit test is turned into an explicit one by having participants think back to the previous study phase, elaborative processing is necessary during study in order to show evidence of new learning.

Because young and older adults exhibited similar amounts of new association priming, the predictions of IDH were not upheld. If older adults had difficulty suppressing activation of the new association, they would have demonstrated <u>more</u> priming than young adults. Perhaps the time interval between learning the association and retrieving it was long enough (approximately 15-30 seconds) for activation to be suppressed. Future research regarding the time course of the activation and inhibition of information should help further specify IDH's claims. For example, research is needed to determine how long information remains active for older adults compared to young adults.

<u>Semantic and Phonological Priming.</u> In addition to the finding that young and older adults were equally able to form new associations in this paradigm, equivalent amounts of semantic and phonological priming were found for both age groups. For example, after responding "laugh" to the homophone and word-stem *beach-l*_____, young and older adults were equally likely to respond again with "laugh" when encountering *beech-l*_____ as when encountering *sand-l*_____. Although NST predicted phonological priming (from *beach-l*____ to *beech-l*____), semantic priming (from *beach-l*____ to *sand-l*____) was expected to be less than phonological priming because of the multiple semantic associates connected to *sand* and the amount of node priming that could travel to each associate. One possible explanation for this finding focuses on the recency of activation of the homophone. The recency of activation of the homophone (*beach*) prior to the semantic associate (*sand*) strengthens connections to that homophone (or lowers the threshold of activation for the homophone). Thus, the homophone is likely to be reactivated when encountering its semantic associate because the connection to the homophone was just recently strengthened, only nine word-stem pairs earlier. Nonetheless, the amount of semantic priming in Experiment 2 was not only smaller than semantic priming in Experiment 1, but it was equivalent to phonological priming rather than greater than phonological priming as in Experiment 1. Thus, semantic priming of new associations appears to be weaker than semantic priming of preexisting associations.

Although Experiment 2 demonstrated semantic and phonological priming of new associations, there was no difference in the amount of priming found when the dominant or subordinate homophone was presented first in the list. One explanation for the null effect of dominance regards the recency of activation, similar to the explanation for semantic priming. That is, finding no effect of dominance is likely due to the recency of presentation of one member of a homophone pair (e.g., *beach-l___*) prior to presentation of the other member (e.g., *beech-l___*). Phonological connections can be strengthened by recent exposure to the phonology. Instead of a weak link between a subordinate homophone and its phonology resulting in dominance effects (as in Experiment 1), recent exposure to the lexical and phonological nodes strengthens the connection between those nodes and allows for priming to transmit more effectively across the recently-strengthened connection. However, although NST maintains that node priming is stronger if the to-be-activated nodes have been recently or frequently activated, NST does not differentiate between the two or suggest that one is more critical than the other. The idea that the recency of activation of one homophone member could be strong enough to override word frequency (or homophone dominance in this case) suggests that recency is a stronger factor than frequency (dominance) in word activation. One future direction for research is to tease apart whether recency or frequency is more powerful in language production and comprehension tasks.

One interesting finding was that new association priming was found in spite of strong repetition priming by both age groups. Repetition priming occurred when participants continued to give the same response to a given letter (e.g., responded *laugh* every time they encountered a word paired with an "l" stem). Although repetition priming occurred fairly frequently, two findings suggest that one age group did not benefit from repetition more than the other age group. First, there were no age differences in the amount of semantic or phonological priming when all experimental pairs where participants repeated a previous response were eliminated. This finding suggests that repetition priming was not the cause of semantic and phonological priming for

either age group. Second, repetition priming occurred equally for both age groups: the same word was given for an experimental pair more often when it had been given previously as a response than when it had not been given previously. Thus, once a response had been recently activated, both young and older adults were primed to give that response again upon encountering the same word stem. Finding similar amounts of repetition priming for both age groups supports previous studies that have found no age differences in repetition priming (Dick, Kean, & Sands, 1989; Hashtroudi, Chrosniak, & Schwartz, 1991, Experiments 1a and 2a; Java & Gardiner, 1991; Light, LaVoie, Valencia-Laver, Albertson-Owens, & Mead, 1992; Light, Singh, & Capps, 1986; Light & Singh, 1987; Moscovitch, 1982; Park & Shaw, 1992), but challenges IDH's prediction that more repetition priming should occur for older adults due to an inability to suppress a previously activated word.

On a final methodological note, evaluation of the post-experiment questionnaires indicated that none of the participants reported trying to use the homophones in any way or trying to respond any differently to the homophone trials. Further, there were no apparent age differences in answers to any of the questions asked by the post-experiment questionnaire.

Response Time. The main finding from response time data was that participants were faster to give a response to the second encounter of an experimental pair when that response matched the response to the first encounter with the experimental pair (i.e., when it showed priming) than when that response did not match (i.e., did not show priming). This effect was found for semantic, phonological, and unrelated conditions, simply suggesting that there is a repetition priming effect for response times: Participants are faster to give a response that they have given only 15 to 30 seconds (nine word stems) previously. The only influence of dominance that was found for Experiment 2 was in the response time analyses for the semantic condition: participants (independent of age) were faster to give a response to a semantic associate of a homophone when the homophone was dominant than when it was subordinate (e.g.,

participants were faster to say *laugh* for *sand-l*____ when it was preceded by *beach-l*____ than they were to say *laugh* for *nut-l*____ when it was preceded by *beech-l*___). Thus, newly-learned associations are activated faster for dominant homophones and their semantic associates than for subordinate homophones and their semantic associates. This finding suggests that dominant homophones are primed faster by their semantic associates than subordinate homophones are primed by their semantic associates, possibly because dominant homophones are generally activated more often than subordinate homophones and therefore dominant homophones have stronger connections to their lexical nodes and their semantic associates. The fact that this effect of dominance did not appear in the analyses using target response as the dependent measure suggests that the effect is only found with more sensitive measures such as response time.

Table 6-1

Background characteristics for young and older adults in Experiment 2

	Group					
	Young adults			Older adults		
Variable	N	Mean	SD	N	Mean	SD
Age*	57	19.26	1.34	50	72.32	6.33
Education (years)*	57	13.25	1.32	50	17.16	2.65
Vocabulary* (max = 25)	57	14.81	3.10	50	20.22	2.91
Forward digit*	57	7.72	1.10	50	7.16	1.15
Backward digit	57	5.79	1.25	50	5.38	1.37
Health (max = 25)	57	7.95	1.41	50	7.70	1.89
MMSE (max = 30)				50	28.30	1.57

Note. Asterisks indicate significant differences between the age groups, $p < .05$.

Table 6-2

Percent of time both stems were completed with the same word in Experiment 2 (participant analysis)

	Prime condition					
	Semantic		Phonological		Unrelated	
Age group	Dominant	Subordinate	Dominant	Subordinate	Dominant	Subordinate
Young						
M	30.4	30.2	30.4	31.6	23.0	25.3
(SD)	(23.6)	(24.5)	(25.9)	(23.8)	(19.4)	(23.5)
Older						
M	28.4	30.3	26.6	28.8	24.4	20.5
(SD)	(18.9)	(21.5)	(23.2)	(26.0)	(23.5)	(18.5)

Note. Dominant and Subordinate in Table 6-2 refer to which type of homophone (dominant or subordinate) came first in the list. For the unrelated condition, either the dominant or subordinate homophone was presented prior to an orthographic (unrelated) control word.

Table 6-3

Percent of time both stems were completed with the same word in Experiment 2 after eliminating previous responses (participant analysis)

	Prime condition					
	Semantic		Phonological		Unrelated	
Age group	Dominant	Subordinate	Dominant	Subordinate	Dominant	Subordinate
Young[a]						
M	28.4	26.6	32.0	27.4	19.5	23.0
(SD)	(24.8)	(23.3)	(28.8)	(25.1)	(20.4)	(24.3)
Older						
M	26.5	29.7	25.2	27.6	20.4	19.7
(SD)	(19.6)	(22.9)	(23.3)	(26.6)	(25.4)	(18.7)

[a] One young adult is missing from this analyses for not having data in each condition.
Note. Dominant and Subordinate in Table 6-3 refers to which type of homophone (dominant or subordinate) came first in the list. For the unrelated condition, either the dominant or subordinate homophone was presented prior to an orthographic (unrelated) control word.

Table 6-4

Mean raw response times (in ms) for the two age groups, matching responses, and dominance order for each prime condition, Experiment 2 (participant analysis)

		Prime condition					
		Semantic		Phonological		Unrelated	
Age group		Dom	Sub	Dom	Sub	Dom	Sub
Young							
Matching							
	M	1544.31	1631.40	1580.72	1517.68	1542.45	1424.79
	SD	(589.03)	(542.44)	(678.17)	(580.10)	(530.30)	(426.28)
Nonmatching							
	M	1757.23	1656.27	1756.36	1675.02	1495.48	1663.97
	SD	(402.21)	(386.14)	(449.40)	(461.56)	(453.86)	(477.39)
Older							
Matching							
	M	1541.85	1716.09	1728.33	1686.58	1518.49	1537.56
	SD	(632.66)	(666.22)	(752.24)	(669.44)	(550.99)	(611.36)
Nonmatching							
	M	1687.99	1627.17	1769.55	1636.11	1585.50	1652.29
	SD	(545.51)	(504.86)	(576.50)	(465.72)	(442.65)	(416.03)

Note. "Dom" refers to the dominant homophone presented first and "Sub" refers to the subordinate homophone presented first. "Matching" and "Nonmatching" refer to whether or not participants' responses matched for an experimental word-stem pair.

Table 6-5

Mean log response times for the two age groups, matching responses, and dominance order for each prime condition, Experiment 2 (participant analysis)

		Prime condition					
		Semantic		Phonological		Unrelated	
Age group		Dom	Sub	Dom	Sub	Dom	Sub
Young							
Matching							
	M	3.15	3.18	3.16	3.15	3.15	3.13
	SD	(.15)	(.15)	(.17)	(.15)	(.15)	(.13)
Nonmatching							
	M	3.22	3.20	3.22	3.20	3.14	3.19
	SD	(.11)	(.10)	(.11)	(.13)	(.13)	(.13)
Older							
Matching							
	M	3.15	3.20	3.20	3.19	3.14	3.15
	SD	(.17)	(.17)	(.18)	(.16)	(.16)	(.17)
Nonmatching							
	M	3.20	3.18	3.21	3.19	3.17	3.19
	SD	(.13)	(.14)	(.15)	(.12)	(.12)	(.11)

Note. "Dom" refers to the dominant homophone presented first and "Sub" refers to the subordinate homophone presented first. "Matching" and "Nonmatching" refer to whether or not participants' responses matched for an experimental word-stem pair.

Table 6-6

Results of Experiment 2 post-experiment questionnaire.

Question	Age group: Young adults	Age group: Older adults
(1) Figured out purpose	3.5%	2%
(3) Reported discarding a first response	40.4%	38.0%
(3a) Of those who discarded first response,% who discarded response on average:		
One time	30.4%	36.8%
Two to three times	30.4%	31.6%
Four to five times	34.8%	21.1%
Six to ten times	4.3%	10.5%
(3b) Reported actively trying not to use the same response twice	40.4%	38.0%
(4) Correctly reported noticing homophones during the experiment	12.3%	4.0%
(4) Reported not noticing anything unusual during the experiment	78.9%	86%
(4) Reported noticing something unusual but were incorrect in their assessment	8.8%	10%
(5) Define homophone	61.4%	58%
Of those defined homophone, % who:		
Noticed homophones in the experiment	45.7%	20.7%
Tried to use the homophones	0%	0%
Responded differently to homophones	0%	0%

Note. The number next to each statement corresponds to the question number on the questionnaire (see Appendix G).

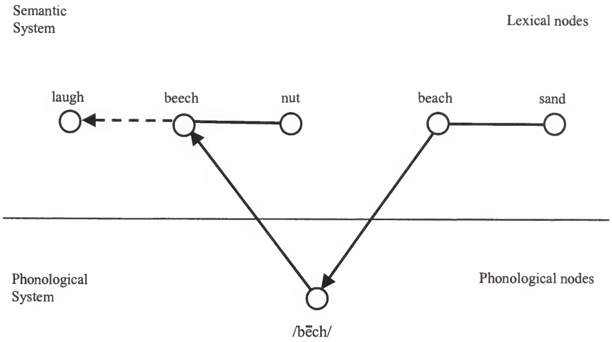
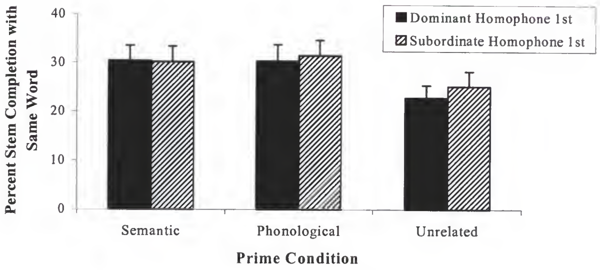


Figure 6-1. Phonological priming of new associations. An example of how priming should spread between *beach* and *laugh* if *laugh* has been newly connected to *beech*.

A



B

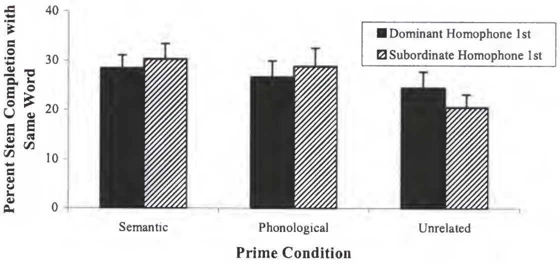


Figure 6-2. Priming for young and older adults in Experiment 2. A) Young Adults. B) Older Adults. The amount of semantic and phonological priming for young and older adults and dominant and subordinate homophones in Experiment 2. The dependent measure, "percent stem completion with the same word," indicates the percent of time participants gave the same word (e.g., *laugh*) upon both presentations of an experimental pair (e.g., *beach-l*___ and *beech-l*____).

CHAPTER 7
GENERAL DISCUSSION

The experiments reported here demonstrated phonological priming of word retrieval in both young and older adults. Phonological priming occurred across retrieval of preexisting associations (e.g., participants completed *beech-s*____ with *sand*, a semantic associate of *beach*) and across retrieval of new associations (e.g., participants completed *beech-l*____ and *beach-l*____ with the same word, *laugh*). Further, associative priming was demonstrated across preexisting and new associations for both age groups; previous research using associative priming only assessed priming of new associations. Finally, older adults do not appear to be at a disadvantage forming new associations versus retrieving preexisting ones when tested in an implicit memory paradigm.

Finding phonological priming of preexisting associations (Experiment 1) in word retrieval complements previous research on phonological priming in a word recognition (Lesch & Pollatsek, 1993; Lukatela & Turvey, 1994). However, Experiment 1 demonstrated phonological priming across longer intervals, namely seconds versus milliseconds. Although Rueckl and Mathew (1999) demonstrated phonological priming of homophones across a three-minute interval, they did not investigate phonological priming of semantic associates. Given that word recognition studies have not found phonological priming of semantic associates when the prime and target are separated by approximately 250 ms (Lukatela & Turvey, 1994), it was slightly surprising to find priming over the longer intervals involved in word retrieval. Although the effect sizes in my paradigm and the word recognition paradigms are not directly comparable (my effect sizes are for percent target completion and the effect sizes for word recognition are in response time), both paradigms show relatively small effects: The effect of phonological priming

in my paradigm was 3.4%-10.9% (compared to 29.1%-47.9% semantic priming), whereas Lesch and Pollatsek (1993) only found that young adults were 9 ms faster to respond to an associate that was primed with a homophone versus primed with an orthographic control word (when the prime and target were presented within 50 ms of one another), and Lukatela and Turvey (1994) found an 11 ms advantage (in Experiment 1 when the prime and target were presented within 100 ms of one another). Therefore, the effect size does not appear to decrease when retrieval (and longer time intervals) are required. It is unclear why phonological priming of semantic associates occurred in retrieval when it has been shown to disappear after 250 ms in recognition. One possibility is that recognition of the prime (*beech*) and activation of the target (*sand*) occurs in less than 250 ms. If this is the case, response time data in word retrieval are misleading because they make priming appear as though it is occurring across a long time course when it is actually happening as quickly as in recognition. Evidence for this possibility comes from response time data: young and older adults produced target words ($\underline{M}$ = 1549.20 ms) faster than non-target words ($\underline{M}$ = 1792.80 ms). However, this possibility is only speculation and needs to be tested in future research. Independent of the time course of phonological priming in retrieval, an important conclusion from Experiment 1 was that the nature and activation of phonological representations appears to be stable across the lifetime, as both young and older adults showed similar amounts of phonological priming of preexisting associations.

Finding phonological (and semantic) priming of new associations (Experiment 2) suggests that young and older adults can form and retrieve new associations under single-trial implicit "study" and "testing" conditions. This finding complements previous word recognition research that found new association priming for naming word pairs or nonwords (Goshen-Gottstein & Moscovitch, 1995; Light et al., 1995, 1996; McKone & Tyrnes, 1999; Poldrack & Cohen, 1997). However, this finding contrasts with previous research that did not find priming of new associations when young and/or older adults explicitly studied word pairs unless the participants were given ample study opportunity and performed elaborative processing on the

word pairs (Graf and Schacter, 1985, 1986; Howard, et al., 1991; Howard, et al., 1986). It is likely that researchers who have not found new association priming either included an explicit component (e.g., explicit study phase, Howard et al., 1986, 1991), or explicit contamination invaded their "implicit" tests. My results suggest that elaboration is not required for the formation of new associations, even when these new associations must be retrieved and not just recognized.

Interestingly, my results found new association priming across phonological and semantic associates, not merely repetition priming of newly learned associates as in previous experiments. In order to see priming across phonological and semantic associates, young and older adults not only had to form a new connection between two lexical nodes (e.g., *beach* and *laugh*), but priming had to spread from phonological (*beech*) or semantic (*sand*) associates to the homophone (*beach*) and then to the new association (*laugh*) (see Figure 6-1). The present results suggest that older adults are able to <u>form</u> new associations and <u>retrieve</u> these associations (across phonologically or semantically related words) at least within approximately 30 seconds of formation.

Both experiments' results supported the predictions of NST by demonstrating phonological priming of preexisting and new associations. Because homophones share a common phonological representation, encountering one member of a homophone pair automatically primes the other member of the homophone pair. Thus, activating associates related to the other member, and activating new associations formed with the other member, is possible through the shared phonological representation. In contrast to support for NST, support was not as strong for the Transmission Deficit hypothesis (TDH). Although Experiment 1's results generally supported the predictions of TDH, Experiment 2's results did not. As predicted, young and older adults performed similarly when asked to retrieve preexisting associations. These are associations that have been repeatedly activated across a lifetime and therefore are less vulnerable to weakening of connections. However, TDH predicts that older adults should have

more difficulty than young adults on tasks that require the formation of new associations. Forming new associations requires that a connection be made between two previously unrelated words. Because connections weaken with old age, older adults should have weaker new connections than young adults. Perhaps older adults require truly implicit learning conditions in order to be as equally able to form new connections as young adults. According to NST, implicit learning facilitates new connection formation because exposure to the new association sends node priming along the newly-formed connections and to the previously uncommitted node(s). Indeed, Light and colleagues' (1995, 1996) research supports this view, as her older adults were required to pronounce nonwords made of compound words or syllables of words; naming is less likely to be influenced by explicit processes than other tasks where older adults are asked to explicitly form new associations and are then tested for these associations through word-stem completion (Howard et al., 1986). The present results extended the findings of Light et al. (1995, 1996) to a generation task: participants generated a unique response to a word stem and then repeated this response on their second encounter with the word stem if the word stem was paired with a homophone or a semantic associate, but not if the word stem was paired with an unrelated word. Experiment 2 found preservation in the implicit formation of new associations, suggesting that the formation of new connections is similar for young and older adults. Perhaps the permanence of the newly-formed connections is problematic (which would be consistent with NST). According to NST, in order for a new connection to become strong, the previously uncommitted nodes must become committed through commitment learning, or repeated pairings (whether implicitly or explicitly). The adults in Experiment 2 only had to maintain their new connection for approximately 30 seconds, and were not asked to do so consciously. Future research should investigate the permanence of newly-formed connections and whether older adults differ from young adults in the amount of commitment learning required to turn uncommitted nodes into committed nodes.

Neither experiment supported the predictions of IDH: that older adults should have demonstrated more phonological priming in both experiments due to an inability to inhibit irrelevant information (i.e., the alternate meaning of the homophones in Experiment 1) and to sustained activation of previously relevant information (i.e., sustained activation of the first response to a homophone pair in Experiment 2). It is possible that older adults did not have trouble inhibiting information in this task because the task did not require a heavy working memory load. Inhibitory deficits are most often found on tasks that strain working memory or demand divided attention. Participants in the present experiments were simply asked to respond to a paired word stem with whatever word came to mind and started with the given letter. Although the task is not as simple as free association where participants can give any response that comes to mind, it is also not as demanding as some working memory tasks, such as long division. Nonetheless, future research needs to further specify how IDH can account for age similarities and differences in priming tasks and new learning tasks.

Role of Dominance in Phonological and Semantic Priming

The experiments reported here were able to control for age differences in dominance ratings by using normative data. Although it may not be practical for researchers to equate young and older adults on dominance, they can control for it by using norms. Controlling for dominance is important when interpreting potential age differences in experiments that use ambiguous words, such as homophones. When stimuli are chosen that control for age differences in dominance, any other differences that are found between the age groups can be attributed to the manipulation and not to poor stimuli selection. Future research on language and aging should consider equating stimuli for young and older adults on variables such as word frequency.

The experiments reported here found that homophone dominance was critical in phonological and semantic priming of preexisting associations but not in priming of new associations, in contrast to NST's predictions of similar dominance effects across the two experiments. These findings have interesting implications for the roles of word frequency and

recency of use on the retrieval of preexisting and new associations. First, dominance (which is similar to word frequency) affects the retrieval of preexisting associations because the strength of connection to the preexisting association is dependent on how frequently that association is activated and how frequently the homophone is activated. That is, the stronger connection between a dominant homophone (e.g., *beach*) and its phonology allows semantic associates (e.g. *sand*) of the dominant homophone to be retrieved upon presentation of the subordinate homophone (e.g., *beech*). Although phonological priming of semantic associates does occur for subordinate homophones upon presentation of the dominant homophone, the effect is lessened because of a weaker connection between the subordinate homophone and its phonology. Secondly, in contrast to preexisting associations, dominance appears to be less critical for the retrieval of new associations if the association has been recently formed. That is, the recency of activation of the new association appears to be more important to retrieval of that association than the dominance of the homophone. Therefore, dominance does not influence the retrieval of newly-formed associations between homophones and an unrelated word.

Phonological Priming and Aging

Until now, research on tip-of-the-tongue (TOT) resolution stood alone in the investigation of phonological priming in old age (James & Burke, 2000; White & Abrams, 2002). James and Burke (2000) found that young and older adults were equally able to resolve TOTs when presented with the entire phonology of the missing word. White and Abrams (2002) further showed that young and young-old (60-72 years of age) adults were more likely to resolve TOTs when primed only with the first syllable of the missing word, whereas old-old adults (73-83 years of age) did not benefit from phonological priming of the first syllable. Researchers believe that TOTs are caused by breakdowns to the phonological nodes of the missing word, and therefore priming the missing phonology was shown to increase resolution in both of these studies, at least for young and young-old adults (but not old-old adults due to greater breakdowns among phonological connections and greater deficits in the transmission of priming along these

connections). However, older adults often report having more TOTs than young adults in everyday life and in the laboratory, likely due to weaker connections to the words' phonology. Because TOTs most often occur on infrequently and/or nonrecently used words, retrieval deficits (and therefore breakdowns across phonological connections) are common. Unlike TOTs, homophones are commonly-used words that are less likely to have weakened connections to phonological nodes. Thus, one implication of finding phonological priming in the present studies is that retrieval of more common words is age invariant (although old-old adults were not tested in these studies, future research might determine whether they benefit from phonological priming of preexisting and new associations). However, another possibility is that phonological priming is similar to repetition priming, which commonly does not differ across age groups (see Light et al., 2000 for a review). Repetition priming requires repeated activation of the same nodes and strengthening of the connections to those nodes so that on a second encounter with a repeated stimulus, faster responses occur. Phonological priming requires activation of, at a minimum, shared phonological nodes (e.g., with *fun* and *sun*, which share the sound /un/). With homophones, phonological priming activates the same phonological node (e.g., /bēch/ for *beach* and *beech*). Finding preserved phonological priming in old age for the experiments presented here could be due to both the use of common words and the similar mechanisms behind phonological priming of homophones and repetition priming. Teasing apart the differences remains a task for future research.

Semantic Priming and Aging

Older adults often show preserved or more semantic priming than young adults in word recognition (e.g., naming) tasks (see Laver & Burke, 1992 for a meta-analysis). Consistent with these findings, older adults showed more semantic priming than young adults in Experiment 1 and equivalent amounts in Experiment 2. Experiment 1 was very similar to word recognition paradigms that required participants to name a word that was preceded by a semantically-related word: Experiment 1 showed that young and older adults produced a semantic associate to a

visually presented homophone when given the first-letter word stem of a common associate. Experiment 2 was a different task than those that have previously facilitated semantic priming: in order to show new association priming, participants had to (1) form a new association between a homophone prime and a participant-generated word, and (2) later retrieve that association when they encountered the semantic associate of the first prime. Given the non-traditional nature of this task, it is surprising that semantic priming occurred at all, but not necessarily surprising that older adults did not show more semantic priming than young adults. Interestingly, new association formation reduces older adults' semantic priming advantage, suggesting that older adults might be at a slight disadvantage when retrieving new associations versus preexisting ones that are dependent on semantic connections.

CHAPTER 8
CONCLUSION

The experiments reported here paint a positive picture for aging adults. First, older adults' retrieval of preexisting information is equal to young adults for phonological information and better than young adults for semantic information. However, these findings must only be interpreted for retrieval of common words; older adults are still known to have difficulty retrieving infrequently- and nonrecently-used information, which result in an increased number of TOTs in old age. These results suggest that older adults need continual exposure to language in order to maintain strong existing connections and to offset potential retrieval deficits.

Second, older adults are able to form new connections and retrieve new associations under implicit conditions. Although their explicit formation and retrieval may place them at a disadvantage, the experiments reported here suggest that the formation of the connections is not affected by age per se, unless encoding conditions are made more difficult (e.g., time pressure, working memory load, divided attention, etc). Rather, older adults' difficulties could be due to the maintenance and strengthening of new connections over time, which may require more exposure to the new information or more elaborative techniques to stabilize the connections between the new information. Another possibility is that older adults have difficulty accessing the newly-learned information under explicit conditions. Whether they can retrieve new associations across longer time periods (e.g., 10 minutes, 1 hour) has yet to be determined, as well as the amount of exposure required to allow for retrieval at longer intervals. Future research should investigate the conditions under which older adults have difficulty sustaining new connections and accessing the information at long time intervals.

APPENDIX A
WRITTEN FREE ASSOCIATION SURVEY

START TIME: ________

1.	days	________	22.	bale	________
2.	sewn	________	23.	groan	________
3.	pride	________	24.	reel	________
4.	owe	________	25.	seam	________
5.	pain	________	26.	straight	________
6.	peak	________	27.	mail	________
7.	flee	________	28.	maul	________
8.	wrap	________	29.	grisly	________
9.	flu	________	30.	cent	________
10.	ewe	________	31.	oh	________
11.	graze	________	32.	high	________
12.	thyme	________	33.	scene	________
13.	belle	________	34.	pare	________
14.	pause	________	35.	tow	________
15.	waist	________	36.	scent	________
16.	lone	________	37.	waste	________
17.	write	________	38.	peek	________
18.	nun	________	39.	beech	________
19.	bruise	________	40.	doe	________
20.	ale	________	41.	ail	________
21.	clique	________	42.	steel	________
43.	gorilla	________	45.	byte	________
44.	one	________	46.	grays	________

47. duel ____________
48. here ____________
49. blew ____________
50. hay ____________
51. plane ____________
52. ferry ____________
53. nay ____________
54. build ____________
55. right ____________
56. quartz ____________
57. site ____________
58. bowled ____________
59. bury ____________
60. loan ____________
61. hi ____________
62. dough ____________
63. root ____________
64. throne ____________
65. vain ____________
66. flue ____________
67. bold ____________
68. earn ____________
69. pale ____________
70. neigh ____________
71. hey ____________
72. ate ____________
73. pear ____________
74. sent ____________
75. mind ____________
76. pane ____________
77. browse ____________
78. bell ____________
79. thrown ____________
80. strait ____________
81. whole ____________
82. dense ____________
83. main ____________
84. billed ____________
85. yoke ____________
86. mined ____________
87. seen ____________
88. naval ____________
89. paws ____________
90. brows ____________
91. knight ____________
92. steal ____________
93. bail ____________
94. pair ____________
95. flew ____________
96. rose ____________
97. sign ____________
98. isle ____________
99. grown ____________
100. jeans ____________
101. wail ____________
102. serial ____________
103. dents ____________
104. sown ____________

105. latter ____________
106. gait ____________
107. maize ____________
108. time ____________
109. see ____________
110. rite ____________
111. coral ____________
112. real ____________
113. hymn ____________
114. guerrilla ____________
115. click ____________
116. hear ____________
117. idle ____________
118. week ____________
119. cereal ____________
120. altar ____________
121. aisle ____________
122. fir ____________
123. pail ____________
124. beach ____________
125. idol ____________
126. rap ____________
127. might ____________
128. gate ____________
129. wring ____________
130. deer ____________
131. seem ____________
132. grizzly ____________
133. hail ____________
134. brews ____________
135. alter ____________
136. vane ____________
137. in ____________
138. urn ____________
139. weak ____________
140. him ____________
141. stare ____________
142. quarts ____________
143. carrot ____________
144. claws ____________
145. maze ____________
146. hale ____________
147. ant ____________
148. eight ____________
149. none ____________
150. bite ____________
151. daze ____________
152. yolk ____________
153. mane ____________
154. toe ____________
155. crews ____________
156. night ____________
157. choral ____________
158. hole ____________
159. ring ____________
160. genes ____________
161. male ____________
162. vein ____________

163. flea ____________
164. ladder ____________
165. sine ____________
166. fairy ____________
167. navel ____________
168. berry ____________
169. route ____________
170. won ____________
171. colonel ____________
172. dual ____________
173. cellar ____________
174. peer ____________
175. sea ____________
176. mall ____________
177. links ____________
178. dear ____________
179. plain ____________
180. aunt ____________
181. blue ____________
182. stair ____________
183. whale ____________
184. pier ____________
185. carat ____________
186. cruise ____________
187. kernel ____________
188. pried ____________
189. fur ____________
190. rows ____________
191. you ____________
192. clause ____________
193. inn ____________
194. lynx ____________
195. seller ____________
196. sight ____________
197. mite ____________

STOP TIME: _________

APPENDIX B
WRITTEN DOMINANCE SURVEY

START TIME: ___________

1.	earn	urn	*equal*	17.	click	clique	*equal*
2.	hymn	him	*equal*	18.	won	one	*equal*
3.	rows	rose	*equal*	19.	claws	clause	*equal*
4.	sign	sine	*equal*	20.	byte	bite	*equal*
5.	mind	mined	*equal*	21.	wrap	rap	*equal*
6.	might	mite	*equal*	22.	hay	hey	*equal*
7.	cruise	crews	*equal*	23.	waste	waist	*equal*
8.	navel	naval	*equal*	24.	bury	berry	*equal*
9.	bail	bale	*equal*	25.	brews	bruise	*equal*
10.	browse	brows	*equal*	26.	peak	peek	*equal*
11.	mane	main	*equal*	27.	beech	beach	*equal*
12.	grown	groan	*equal*	28.	loan	lone	*equal*
13.	maze	maize	*equal*	29.	mail	male	*equal*
14.	pause	paws	*equal*	30.	hear	here	*equal*
15.	guerrilla	gorilla	*equal*	31.	sea	see	*equal*
16.	click	clique	*equal*	32.	click	clique	*equal*

33.	won	one	*equal*	40.	brews	bruise	*equal*
34.	claws	clause	*equal*	41.	peak	peek	*equal*
35.	byte	bite	*equal*	42.	beech	beach	*equal*
36.	wrap	rap	*equal*	43.	loan	lone	*equal*
37.	hay	hey	*equal*	44.	mail	male	*equal*
38.	waste	waist	*equal*	45.	hear	here	*equal*
39.	bury	berry	*equal*	46.	sea	see	*equal*
47.	right rite	write	*equal*	61.	build	billed	*equal*
48.	reel	real	*equal*	62.	fur	fir	*equal*
49.	dough	doe	*equal*	63.	dense	dents	*equal*
50.	steel	steal	*equal*	64.	pried	pride	*equal*
51.	coral	choral	*equal*	65.	duel	dual	*equal*
52.	night	knight	*equal*	66.	flea	flee	*equal*
53.	kernel	colonel	*equal*	67.	time	thyme	*equal*
54.	bowled	bold	*equal*	68.	owe	oh	*equal*
55.	stair	stare	*equal*	69.	hole	whole	*equal*
56.	deer	dear	*equal*	70.	cereal	serial	*equal*
57.	aunt	ant	*equal*	71.	inn	in	*equal*
58.	aisle	isle	*equal*	72.	sewn	sown	*equal*
59.	nay	neigh	*equal*	73.	quartz	quarts	*equal*
60.	idle	idol	*equal*	74.	root	route	*equal*

75.	pain		pane	*equal*
76.	mall		maul	*equal*
77.	gait		gate	*equal*
78.	bell		belle	*equal*
79.	pail		pale	*equal*
80.	vein	vain	vane	*equal*
81.	scene		seen	*equal*
82.	plane		plain	*equal*
83.	links		lynx	*equal*
84.	straight		strait	*equal*
85.	weak		week	*equal*
86.	blue		blew	*equal*
87.	hi		high	*equal*
88.	eight		ate	*equal*
89.	nun		none	*equal*
90.	wail		whale	*equal*
91.	ladder		latter	*equal*
92.	wring		ring	*equal*
93.	days		daze	*equal*
94.	carrot		carat	*equal*
95.	flew	flu	flue	*equal*
96.	grays		graze	*equal*
97.	tow		toe	*equal*
98.	genes		jeans	*equal*
99.	ale		ail	*equal*
100.	cellar		seller	*equal*
101.	pear	pair	pare	*equal*
102.	yolk		yoke	*equal*
103.	altar		alter	*equal*
104.	grizzly		grisly	*equal*
105.	ferry		fairy	*equal*
106.	hail		hale	*equal*
107.	ewe		you	*equal*
108.	throne		thrown	*equal*
109.	site	cite	sight	*equal*
110.	pier		peer	*equal*
111.	sent	cent	scent	*equal*

STOP TIME: ____________

APPENDIX C
LISTS OF HOMOPHONES

Table C-1

Final list of stimuli from norming data and pilot studies

Homophone	Dominance	Target(s)[a]	Percent Stem-Completion (Pilot Study 2) Young	Older	Orthographic Control[b]
ail	dominant	ill	57.00	80.00	aim
ale	subordinate	beer	75.00	100.00	
alter	dominant	ego	78.57	50.00	after
altar	subordinate	wedding	58.33	50.00	
aunt	dominant	uncle	85.71	100.00	
ant	subordinate	hill	71.40	66.67	act
bail	dominant	jail	84.62	85.71	
bale	subordinate	hay	75.00	66.67	bake
beach	dominant	sand, shore	53.85	50.00	
beech	subordinate	nut	57.14	66.67	batch
berry	dominant	fruit	46.15	14.29	
bury	subordinate	dead, dig		85.71	burn
bite	dominant	eat	85.71	60.00	bike
byte	subordinate	giga	57.14	66.67	
blue	dominant	red	75.00	80.00	blur

Table C-1. Continued

Homophone	Dominance	Target(s)[a]	Percent Stem-Completion (Pilot Study 2) Young	Older	Orthographic Control[b]
blew	subordinate	nose	61.54	57.14	
browse	dominant	look	50.00	33.33	brought
brows	subordinate	eye	46.15	28.57	
carrot	dominant	orange	71.43	50.00	
carat	subordinate	diamond	53.85	100.00	cart
cereal	dominant	breakfast, bowl, bran, box	42.00	75.00	conceal
serial	subordinate	number	75.00	85.71	
coral	dominant	reef	83.33	50.00	
choral	subordinate	music	14.29	57.14	chore
click	dominant	mouse	42.86	11.11	clock
clique	subordinate	group, gang	46.15	80.00	
cruise	dominant	control	38.46	12.50	
crews	subordinate	row(ing)	75.00	44.44	cross
earn	dominant	money	83.33	88.89	
urn	subordinate	ashes	42.86	42.86	urge
fur	dominant	coat	76.92	66.67	
fir	subordinate	tree	66.67	87.50	fin
gate	dominant	open	71.43	75.00	
gait	subordinate	walk	21.43	77.78	grit
gorilla	dominant	ape, animal	71.43	90.00	granola
guerrilla	subordinate	war(fare)	75.00	88.89	

Table C-1. Continued

Homophone	Dominance	Target(s)[a]	Percent Stem-Completion (Pilot Study 2) Young	Older	Orthographic Control[b]
graze	dominant	goat, grass, green	62.50	90.00	grade
grays	subordinate	white(s)	46.15	12.50	
him	dominant	her	100.00	85.71	hid
hymn	subordinate	church, choir, chorus, carol	71.43	75.00	
idle	dominant	hands	42.86	22.22	ideal
idol	subordinate	god	28.57	60.00	
in	dominant	out	100.00	83.33	it
inn	subordinate	motel	53.85	75.00	
loan	dominant	bank	57.14	55.56	load
lone	subordinate	ranger	57.14	42.86	
main	dominant	street	42.86	33.33	
mane	subordinate	hair, horse	85.00	100.00	mate
mall	dominant	shop, store	69.23	90.00	
maul	subordinate	hurt	28.57	40.00	mauve
maze	dominant	rat	38.46	28.57	muse
maize	subordinate	corn	66.67	62.50	
night	dominant	day, dark	85.71	75.00	
knight	subordinate	armor	14.29	33.33	knuckle
none	dominant	zero	35.71	50.00	note
nun	subordinate	pope, priest	85.00	44.44	
one	dominant	two	61.54	42.86	

Table C-1. Continued

Homophone	Dominance	Target(s)[a]	Percent Stem-Completion (Pilot Study 2) Young	Older	Orthographic Control[b]
won	subordinate	lost	57.14	50.00	wow
pair	dominant	shoes	30.77	57.14	
pare	subordinate	apple	42.86	83.33	pave
pause	dominant	stop, second	61.54	60.00	
paws	subordinate	dog	91.67	85.71	pans
peak	dominant	mountain	46.67	60.00	park
peek	subordinate	aboo	50.00	88.89	
peer	dominant	look	42.86	60.00	peel
pier	subordinate	water	71.43	50.00	
plane	dominant	fly, fare	75.00	40.00	
plain	subordinate	jane	53.85	83.33	plaid
quarts	dominant	pints	83.33	77.78	quaint
quartz	subordinate	stone	14.29		
real	dominant	estate	46.15	71.43	
reel	subordinate	in	66.67	100.00	rail
right	dominant	wrong, wing	57.14	88.89	
rite	subordinate	passage	21.43	42.86	ripe
ring	dominant	finger	83.33	85.71	
wring	subordinate	neck	15.38	44.44	wrong
scent	dominant	odor	46.15	44.44	stunt
cent	subordinate	dime, dollar	57.00	62.50	

Table C-1. Continued

Homophone	Dominance	Target(s)[a]	Percent Stem-Completion (Pilot Study 2) Young	Older	Orthographic Control[b]
sign	dominant	language	50.00	37.50	sigh
sine	subordinate	cosine, curve	83.30	70.00	
stair	dominant	case, climb	57.14	80.00	stain
stare	subordinate	at	53.85	62.50	
steal	dominant	rob	14.29	33.33	
steel	subordinate	iron	23.08	66.67	steep
thrown	dominant	ball	46.15	42.86	throat
throne	subordinate	king	84.62	100.00	
vein	dominant	blood	58.33	66.67	verb
vane	subordinate	weather	15.38	44.44	
waste	dominant	garbage	46.15	66.67	
waist	subordinate	hips, high	69.23	90.00	wait
whale	dominant	ocean		14.29	
wail	subordinate	cry	69.23	44.44	wall
whole	dominant	half, hearted	46.15	60.00	
hole	subordinate	dig	38.46	60.00	hope
you	dominant	me	69.23	66.67	yes
ewe	subordinate	lamb	28.57	62.50	

[a] Multiple targets word used for 19 homophones (see Pilot Study 1).
[b] Orthographic control words used in Experiment 1.
Note. Percentages are missing within an age group for three homophones because these homophone-target pairs were not tested in that age group

Table C-2

Foil homophones used in Experiment 1

Condition						
Semantic		Phonological		Unrelated	Target
grown	(dominant)	***groan***	(subordinate)	growl	tall
build	(dominant)	***billed***	(subordinate)	banned	house
bell	(dominant)	***belle***	(subordinate)	belt	ring
ate	(dominant)	***eight***	(subordinate)	ace	dinner
days	(dominant)	***daze***	(subordinate)	dame	nights
seen	(dominant)	***scene***	(subordinate)	score	heard
mined	(subordinate)	***mind***	(dominant)	mint	coal
bowled	(subordinate)	***bold***	(dominant)	bald	over
pried	(subordinate)	***pride***	(dominant)	prize	open
pane	(subordinate)	***pain***	(dominant)	paid	window

Table C-3

List of homophones and semantic associates used in Experiment 2

Homophone	Associate	Homophone	Associate
ail	sick*	cereal	breakfast
ale	beer	choral	sing*
altar	church*	click	clock*
alter	change*	clique	group
ant	bug*	coral	reef
aunt	uncle	crews	boat*
bail	bond*	cruise	ship*
bale	hay	earn	money
beach	sand	ewe	sheep*
beech	nut	fir	tree
berry	fruit	fur	coat
bite	teeth*	gait	walk
blew	wind*	gate	open
blue	sky*	gorilla	ape
brows	eyes	grays	whites
browse	look	graze	cow*
bury	dead	guerilla	warfare
byte	computer*	him	her
carat	diamond	hole	ground*
carrot	orange	hymn	song*
cent	penny*	idle	lazy*
idol	worship*	quartz	stone
in	out	real	fake*
inn	hotel*	reel	fish*

Table C-3. Continued.

Homophone	Associate	Homophone	Associate
knight	armor	right	wrong
loan	bank	ring	finger
lone	ranger	rite	passage
main	street	scent	smell*
maize	corn	serial	number
mall	shop	sign	language
mane	horse	sine	cosine
maul	hurt	stair	climb
maze	lost*	stare	gaze*
night	day	steal	take*
none	zero	steel	metal*
nun	priest	throne	king
one	two	thrown	ball
pair	shoes	urn	ashes
pare	apple	vane	weather
pause	stop	vein	blood
paws	dog	wail	cry
peak	mountain	waist	hips
peek	see*	waste	garbage
peer	friend*	whale	fish*
pier	dock*	whole	half
plain	simple*	won	lost
plane	fly	wring	clothes*
quarts	pints	you	me

Note. Asterisks (*) indicate a change in semantic associate from Experiment 1 to Experiment 2.

APPENDIX D
ADULT PARTICIPANT QUESTIONNAIRES

DATE: PARTICIPANT #: EXPERIMENT NAME & #:

YOUNGER ADULT PARTICIPANT QUESTIONNAIRE

1. Date of Birth:

2. Age:

3. Gender:

4. Are you: ☐ Right-handed ☐ Left-handed ☐ Ambidextrous

5. What Psychology classes have you taken (e.g., PSY 2013)?

6. What is the **TOTAL** number of years you have spent in school (*e.g. 12=high school graduate*)?

7. Is English your first language? [check one]:
   ☐ Yes ☐ No
   If "No",
   - what is your first language?: ________________
   - how many years experience do you have with English?: ________________
   - which language do you speak most often (e.g., at home)?: ________________

8. What is your ethnicity [check one]?
   ☐ White
   ☐ African American
   ☐ American Indian or Alaskan Native
   ☐ Asian or Pacific Islander
   ☐Hispanic
   ☐ Other (please specify): ________________

9. How would you rate your health for a person of your age? [check number]:

	Poor				Average			Excellent	
1	2	3	4	5	6	7	8	9	10

10. Do you have any **vision** or **hearing** problems? [check one]:
    ☐ No ☐ Yes
    If "yes", please explain and indicate if they are corrected *(e.g., nearsighted and wear glasses):*

11. Please list any medical problems you currently have or have experienced in the past that could affect your cognitive performance.

DATE: PARTICIPANT #: EXPERIMENT:

ADULT PARTICIPANT QUESTIONNAIRE

1. Date of Birth:

2. Age:

3. Sex:

4. Are you: ☐ Right-handed ☐ Left-handed ☐ Ambidextrous

5. What is the **TOTAL** number of years of formal schooling (e.g., B.A. = 16 years):

6. Is English your first language? [check one]:
   ☐ Yes ☐ No
   If "no",
   - what is your first language?: ________________
   - how many years experience do you have with English?: ________________
   - which language do you speak most often (e.g., at home)?: ________________

7. What is your ethnicity [check one]?
   ☐ White
   ☐ African American
   ☐ American Indian or Alaskan Native
   ☐ Asian or Pacific Islander
   ☐Hispanic
   ☐ Other (please specify): ________________

8. How would you rate your health for a person of your age? [circle number]:

	Poor				Average			Excellent	
1	2	3	4	5	6	7	8	9	10

9. Do you have any **vision** or **hearing** problems? [check one]:
   ☐ No ☐ Yes
   If "yes", please explain and indicate if they are corrected *(e.g., nearsighted and wear glasses):*

10. Are you taking any prescription medicines? [check one]
    ☐ No ☐ Yes
    If "yes", please indicate what for *(e.g., high blood pressure):*

11. Please list any medical problems you currently have or have experienced in the past that could affect your cognitive performance.

APPENDIX E
DIGIT SPAN TESTS

	FORWARD I		FORWARD II	
3	5-2-8		1-7-4	
4	3-4-6-9		7-2-8-6	
5	7-5-1-3-6		4-9-3-1-5	
6	9-1-6-3-7-4		3-6-4-2-8-7	
7	4-1-7-9-3-8-6		5-3-1-8-4-6-2	
8	8-5-1-9-2-6-4-7		9-8-2-6-1-5-7-3	
9	2-7-9-1-8-2-5-3-4		7-1-3-9-4-2-5-6-8	
10	1-5-9-2-6-3-9-5-2-8		2-5-4-1-9-7-8-1-9-2	
11	3-8-4-7-9-2-5-3-7-4-9		5-7-4-8-6-5-2-9-1-5-4	
12	6-7-4-2-6-1-4-5-1-7-3-9		8-9-5-4-9-6-1-3-7-8-2-1	

	BACK I		BACK II	
2	2-4		5-8	
3	6-2-9		4-1-5	
4	4-9-6-8		3-2-7-9	
5	1-5-2-8-6		6-8-1-4-3	
6	5-3-9-4-8-2		7-2-1-8-5-6	
7	8-1-2-9-3-6-5		4-7-3-5-9-2-8	
8	9-4-1-7-6-8-5-3		2-7-8-1-6-9-5-3	
9	6-2-5-8-1-3-9-2-7		5-2-7-8-5-9-1-4-3	
10	4-8-2-1-6-5-3-6-2-9		6-9-4-2-5-9-8-1-7-5	

APPENDIX F
EXPERIMENT 1 POST-EXPERIMENT QUESTIONNAIRE

The following are a list of questions concerning your participation in the experiment. Please try to answer these as honestly as you can. Please provide any extra information that you think is relevant. If you do not understand a question, please let the experimenter know. Thank you.

(1) What do you think was the purpose of the stem-completion task you just finished?

(2) What was your general strategy in completing the word-stems?

(3) Did you ever discard any of your first responses in order to give a different, or more "appropriate" response?

(a). How often do you think you did this (please try and be specific)?

(4) Did you notice anything unusual about the words that were paired with the stems?

(a). What specifically did you notice?

(b). What brought this to your attention?

(c). When did you notice this (i.e., at what point during the experiment, e.g., after 5 stems)?

AFTER ABOVE QUESTIONS HAVE BEEN ASKED:

(5) Are you familiar with "homophones"? Did you notice homophones in the words that were presented with the stems? If so, could you give an example? Did you try to use these in any way?

APPENDIX G
EXPERIMENT 2 POST-EXPERIMENT QUESTIONNAIRE

The following is a list of questions concerning your participation in the experiment. Please try to answer these as honestly as you can. Please provide any extra information that you think is relevant. If you do not understand a question, please let the experimenter know. Thank you.

(1) What do you think was the purpose of the stem-completion task you just finished?

(2) What was your general strategy in completing the word-stems?

(3) Did you ever discard any of your first responses in order to give a different, or more "appropriate" response?

(a). How often do you think you did this (please try and be specific)?

(b). Did you actively try not to use the same response twice?

(4) Did you notice anything unusual about the words that were paired with the stems?

(a). What specifically did you notice?

(b). What brought this to your attention?

(c). When did you notice this (i.e., at what point during the experiment, e.g., after 5 stems)?

AFTER ABOVE QUESTIONS HAVE BEEN ASKED:

(5) Could you define what a "homophone" is? If they correctly define it:

(a) Did you notice homophones in the words that were presented with the stems?

(b) If so, could you give an example?

(c) Did you try to use the homophones in any way when completing the stem? If so, how?

(d) Did you respond to the homophone word-stems any <u>differently</u> than you responded to any of the other word-stems?

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BIOGRAPHICAL SKETCH

Katherine Kay White was born in Greencastle, Indiana, on February 19, 1975. Shortly after her birth, her family moved to Tuscaloosa, Alabama, where she was raised. There she attended Central High School. After graduating in 1993, Katherine enrolled in Rhodes College in Memphis, Tennessee, with a Presidential Scholarship from the college. In 1997, she graduated *cum laude* from Rhodes with a Bachelor of Arts degree and departmental honors in psychology. Katherine received her Master of Science degree in psychology from the University of Florida in May, 1999. She completed her Ph.D. in psychology at the University of Florida in December 2002. Her research interests include memory and language processes in young and older adults. After graduating from the University of Florida, Katherine was employed at Educational Testing Services conducting research on cognitive aging.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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